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SURGERY OF THE INTRINSIC MUSCLES OF THE HAND OTHER THAN THOSE PRODUCING OPPOSITION OF THE THUMB *

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With the progress of surgery certain finer aspects, which only a few decades ago would have seemed unimportant, are now essential.

The intrinsic muscles of the hand, though tiny, are important because they complete, with the long extensors and long flexors, the muscle balance in the hand. Normal position, normal motion, and even strength of the grip of the hand are dependent on this nice balance of these three sets of muscles.

With loss of action of the intrinsic muscles the thumb cannot oppose or adduct. It lies to the side of the hand. The carpal and metacarpal arches are flat and the fingers are clawed. They cannot simultaneously flex in their proximal joints and extend in their distal two joints, and are practically devoid of lateral motion. The hand has lost its skill and finer movements.

In hands not suitable for nerve repair, much of this imbalance can be

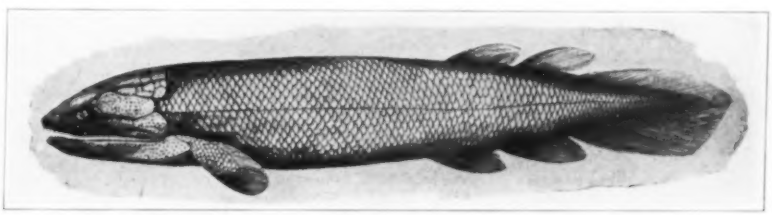

FIG. 1

Following the sharks, and just before the lung fishes, came the crossopterygii, or fringe fins, with fleshy, jointed fins. It is conceded that this is the subclass which emerged from the water to become amphibia, and developed lungs and limbs for terrestrial existence. (*Reproduced from "Fishes" by David Starr Jordan, by courtesy of D. Appleton-Century Co., Inc.*)

* Read at the Annual Meeting of The American Academy of Orthopaedic Surgeons at New Orleans, Louisiana, January 16, 1941.

corrected surgically by tendon transfers. Cases include those of ulnar-nerve paralysis and those of paralysis of ulnar and median nerves. Also included are those with loss of intrinsic-muscle action of one or several digits. The correction of these has been found worth while in improving the function of the hand. It is possible, if the tissues are sufficiently flexible, to restore adduction of the thumb, curvature of the carpal and metacarpal arches, some lateral motion of the fingers, and the ability to flex their proximal and extend their distal two joints simultaneously.

FIG. 2-A

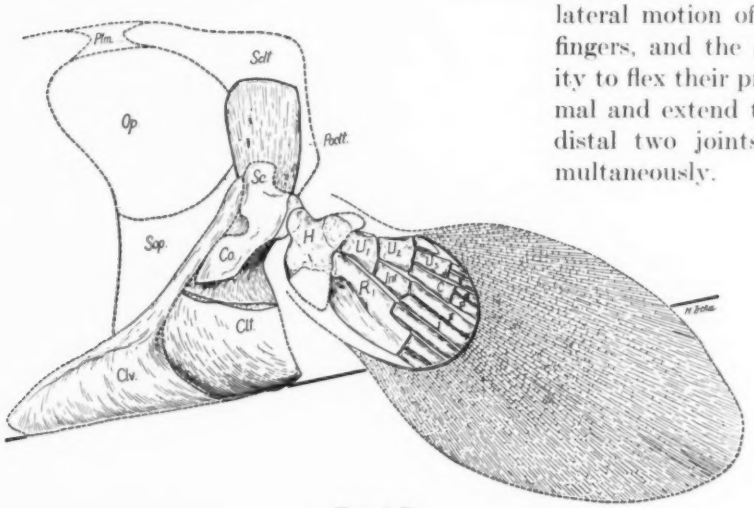

FIG. 2-B

Drawings show the story in fossils of how the pectoral fin of this early crossopterygian developed into the forelimb of the earliest known amphibian, eryops, thus changing from the multirayed fin to the five-digit type. (*Reproduced by courtesy of The American Philosophical Society*[12].)

Fig. 2-A: Original specimen of a pectoral fin of the fringe-fin fish, sauripterus taylori Hall, from the upper Devonian of Pennsylvania,—the conceded ancestor of the amphibia and all the vertebrates that followed.

Fig. 2-B: Median view of the right side of a reconstruction of the pectoral girdle and paddle of sauripterus taylori.

The function of opposition of the thumb, having been already discussed in a former paper[6], is omitted in this one.

PHYLOGENETICS OF THE INTRINSIC MUSCLES OF THE HAND

From a search through the literature, and by dissection of the hands

of reptiles, mammals, monkeys, higher apes, and man for the origin of the intrinsic muscles, the author has reached the following conclusions:

Of all the muscles of the upper extremity, the intrinsic ones of the hand are primordial. They date back to the early fish where there was no arm but only a pectoral fin, the forerunner of the hand. Thus the hand in phylogeny preceded the arm, which developed later from higher cervical segments. The fish has not yet a neck, the bones of the pectoral fin articulating with the skull. Our intrinsic muscles are still supplied by the lower two nerves of the brachial plexus. The arm developed later from the neck for terrestrial existence.

The tetrapod, or four-limbed arrangement which became standard, commenced in the fish with pectoral and pelvic fins. The independent muscle ac-

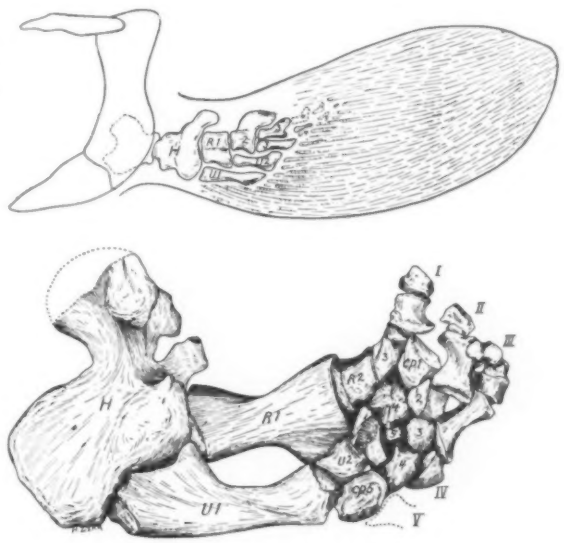

FIG. 2-C

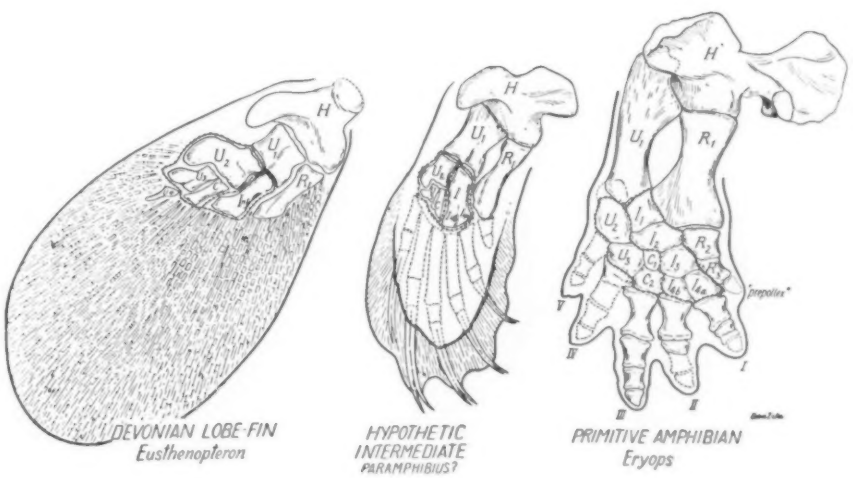

FIG. 2-D

Fig. 2-C: Comparison of the pectoral girdle and limb of a crossopterygian fish with that of eryops of the stegocephalian type, the earliest known amphibian showing homologous parts, according to Romer's theory.

Fig. 2-D: Transformation from the multirayed crossopterygian paddle to the pentadactylate hand of eryops and all subsequent vertebrates.

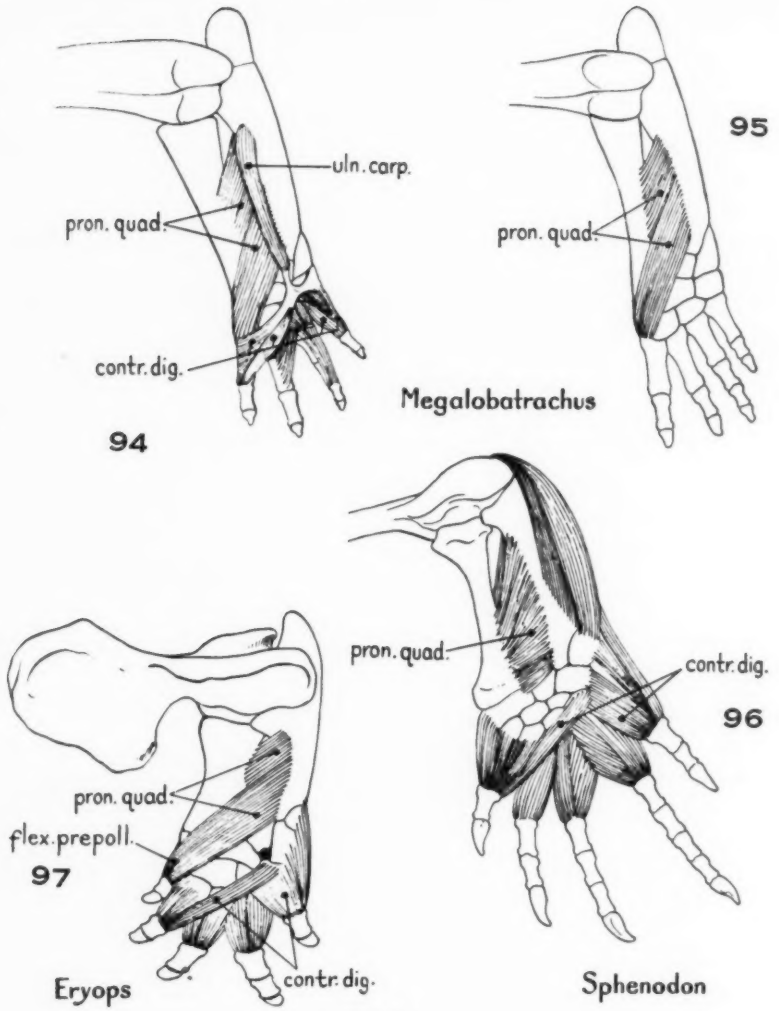

FIG. 3-A

Intrinsic hand muscles are well developed in amphibia, and, in fact, are the only muscles that control the digits. The arm muscles stop at the carpus or metacarpus. The arm developed after the hand from higher cervical segments. The intrinsic muscles in man are supplied by the lower segments of the eighth cervical and the first thoracic nerves, and the arm by higher segments up to the fifth cervical. The surprising development of the intrinsic muscles in amphibians is shown in this dissection of the hand of the giant salamander of Japan, megalobatrachus. (*Reproduced by courtesy of the Bulletin of the American Museum of Natural History*[30].)

Comparison of the deepest layer of forearm muscles and the contrahentes digitorum of megalobatrachus with those of the reptile sphenodon, and their inferred restoration in eryops.

tion of the rays of the pectoral fin was by the anlage of our intrinsic hand muscles. In development from fish through amphibians to man, the multirayed fin of the fish was reduced to the pentadactylate type. It is generally conceded that it was the crossopterygian fish, called "fringed

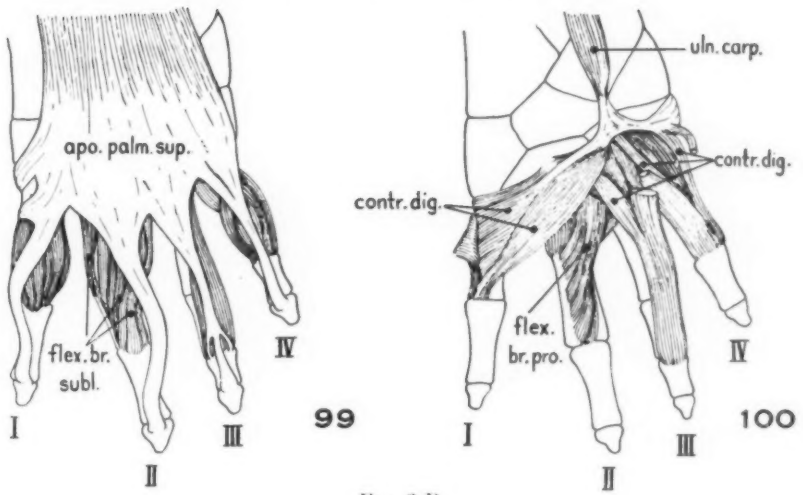

FIG. 3-B

99: Dissection of the hand of megalobatrachus showing superficial flexors and their attachment to the palmar fascia.
100: Showing deep flexors and their relation to the ulnocarpalis.

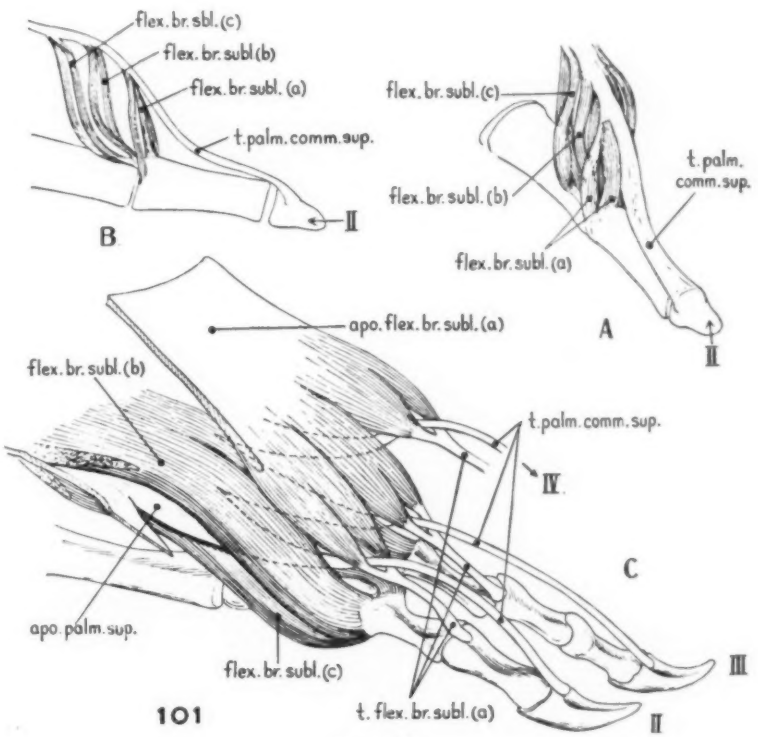

FIG. 3-C

Dissection of the second digit of megalobatrachus (*A* and *B*) and of the second, third, and fourth digits in the reptile sphenodon (*C*) to show the relation of the digital flexors to the palmar aponeurosis.

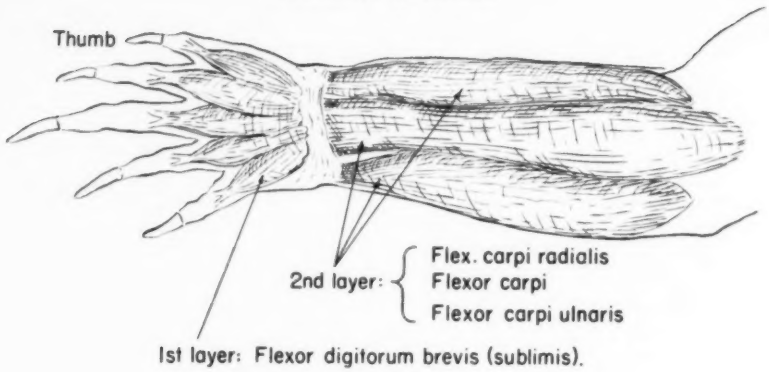

FIG. 4-A

Ventral view of the right foot of an alligator.

In reptiles, as in amphibians, the hand is thick and meaty from intrinsic muscles. All muscles controlling the digits are of the brevis type, except the long flexor profundus,—the only forearm muscle which acts on the digits. Even it is still bipartite. In the gradation to mammals, the extensor brevis and flexor sublimis became long muscles by fusing end to end over the carpus with the forearm muscles and then separating from the carpus. The predominance of the intrinsic muscles in reptiles is shown in these sketches from the hand of an alligator.

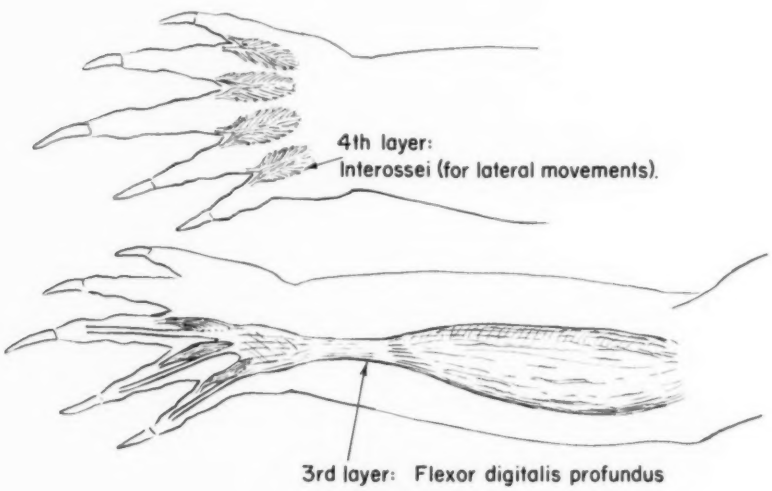

FIG. 4-B

Ventral view of the right front foot of an alligator.

fins", the forerunners of the lung fishes, which emerged from the water, evolved to amphibia, and developed lungs and feet for terrestrial existence.

The intrinsic muscles of the hand are found to be already highly developed in the amphibia, and in this class they have sole control of the digits. As yet no forearm muscles moved the digits, all extensors and flexors of the digits being of the "brevis" type, their origin not being above the carpus. The same high development of intrinsic muscles runs through reptilians, and even here the long flexor profundus is the only

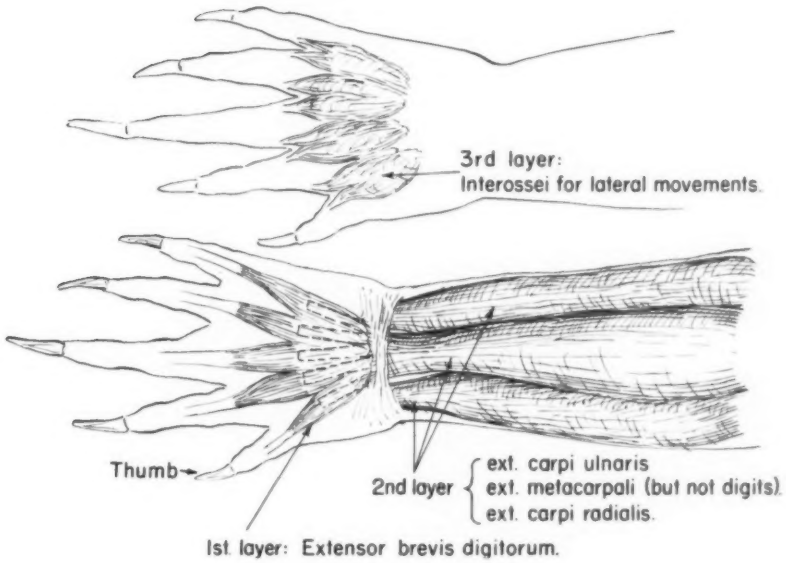

FIG. 4-C

Dorsal view of the right front foot of an alligator.

forearm muscle which has joined to the intrinsic muscles across the carpal ligament, so as to move the digits.

All other forearm muscles now did not insert below the carpus or metacarpals. It was an easy step, therefore, in the gradation to mammals, for this tendinous attachment or connection across the carpus merely to loosen from the carpus, with the result that the long muscle in the forearm was continuous with the one in the hand. This is apparently the development of the long extensors and long flexor sublimis in man, which now control our digits from the forearm. Recently the author had two patients who had two slips of the atavistic extensor brevis. In the human foot there is still an extensor brevis, and the flexor sublimis is a brevis.

In monkeys and higher apes the intrinsic muscles of the hand are well developed and their arrangement is so similar to that of man that the variations are small and rather exceptional. The four or five contrahentes of most mammals and monkeys, which are separated from the interossei by the deep branch of the ulnar nerve, have been reduced in man to just the adductor of the thumb.

Palmar interossei in most mammals are six or seven; and in primates, five or six; but in man there are only three, because four have fused with the dorsal interossei, thus accounting for the latter's double insertion.

In primates the palmar interossei and lumbricales insert in the lateral extension of the extensor tendons, and the dorsal interossei insert only on the phalanges. The axis of the interossei in man and most primates is the third digit, but in some prosimians it is the fourth.

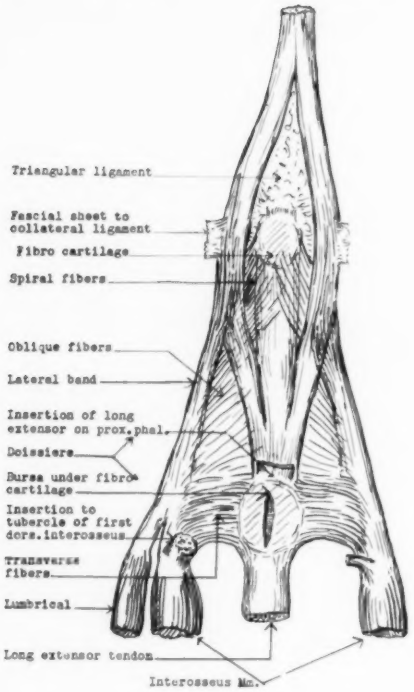

FIG. 5-A

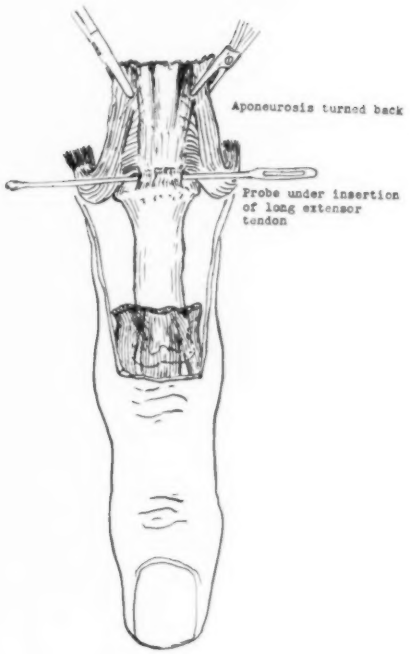

FIG. 5-B

Fig. 5-A: View of the under surface of the dorsal aponeurosis of the right index finger. This complicated aponeurosis coordinates the muscle action of the long extensor, the interossei, and the lumbricales.

Fig. 5-B: The *dossière* ("cloth over the back of a throne") is turned back to show the insertion in the proximal phalanx of the long extensor.

ANATOMY AND FUNCTION OF THE INTRINSIC MUSCLES

In the literature regarding the function of the intrinsic muscles controlling the fingers one finds such wide divergence of opinion that it is evident that the subject is still in the controversial stage. Textbooks of anatomy largely agree, but are incomplete, as they fail to consider synergic

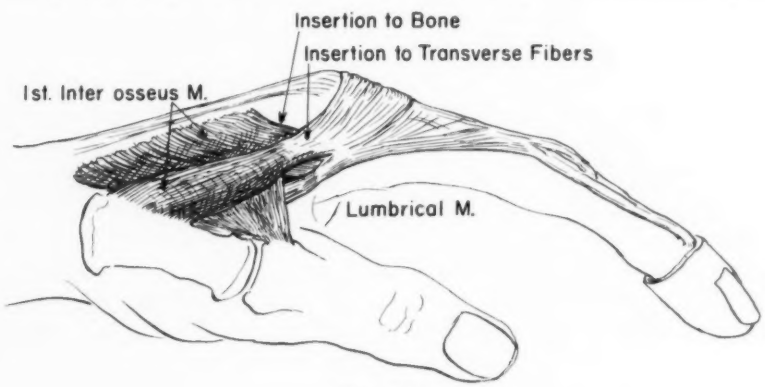

FIG. 6-A

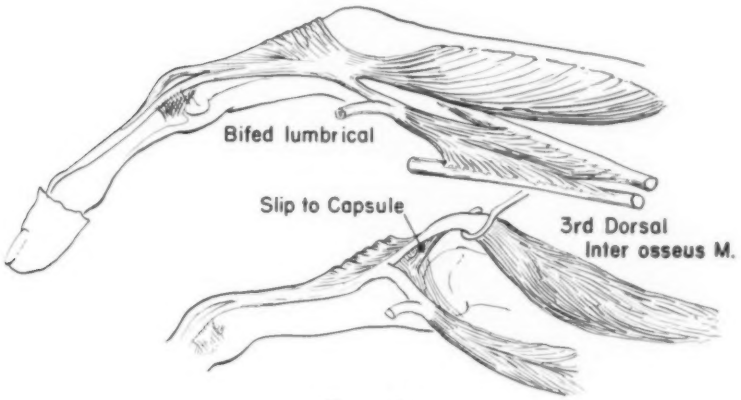

FIG. 6-B

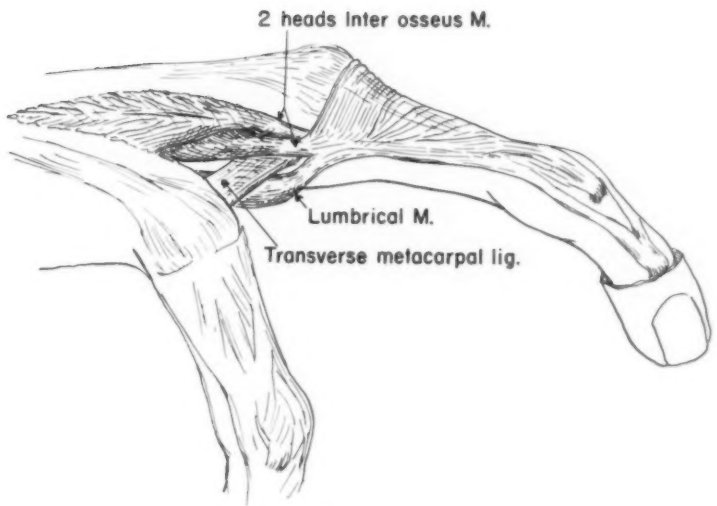

FIG. 6-C

Figs. 6-A, 6-B, 6-C, and 6-D show types of insertions. Lumbricales insert into the dorsal aponeurosis; interossei by several heads from fairly distinct muscle bellies insert variously into the phalangeal tubercle (Figs. 6-A, 6-B, 6-C, and 6-D), into the capsule of the joint (Fig. 6-B), and into the aponeurosis (Figs. 6-A, 6-B, and 6-C).

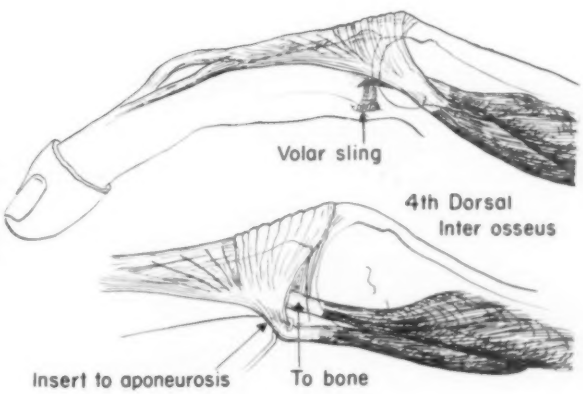

FIG. 6-D

action between the muscles; stabilization and coordination; and the conception that the lumbricales and interossei have a different action when the proximal finger joints are in their first half (45 degrees) of flexion than when they are in their second half, and a different function, depending on whether or not the extensor tendon stabilizes the proximal finger joints in extension. Embalmed cadavera are worthless for this study when compared with fresh hands. Recent advances are to be found in the contributions of Montant and Baumann, Hauck, Mason, Salsbury, and Hopper. In cooperation with L. D. Howard, Jr. and Donald R. Pratt, the author has dissected fresh cadavera, and made observations in the living during operations on the hands. He also has made direct examinations of normal and crippled hands in movement. After reviewing all available sources, the following conception of the anatomy and function has been reached.

The Dorsal Aponeurosis or Extensor Assembly

The thin sliding dorsal aponeurosis of a finger is a complicated mechanism which makes for ingenious coordination in action of the long extensors and flexors, and the lumbricales and interossei, so that the complete motion of flexion and extension of a finger is smoothly carried out; various muscles take over the action in turn, although each individual muscle has but a limited excursion of motion.

The tendons of the interossei and more laterally of the lumbricales fuse into the sides of this aponeurosis where they can be readily palpated in the finger. They first give off fibers transversely, as a sling over the dorsum of the proximal phalanx, for flexion of the proximal finger joint, and then continue on as the lateral band on each side of the finger to divide, the median fibers extending the middle joint and the lateral ones the distal.

The long extensor tendon, as it spreads into the aponeurosis, gives off first a central deep ribbon from its under surface to extend the proximal finger joint, and then divides into three slips,—the central one for the middle joint and the two lateral ones fusing with the lateral bands to extend the distal joint.

The Shift of the Aponeurotic Sleeve

At the base of the finger there is a remarkable mechanism which allows the conjoined tendons of the interossei and lumbricales either to flex the proximal finger joint or to extend the distal two finger joints according to whether the aponeurotic sleeve shifts distalward or proximalward, respectively. The transverse fibers, constituting the broad strap of dorsal aponeurosis across the back of the proximal phalanx, form the dorsal two-thirds of the sleeve. The ventral portion consists of a narrow band, blended with the joint capsule, and joining to the under surface of the aponeurosis laterally. The dorsal part of the sleeve, in company with the extensor tendon, can be passively made to shift on the phalanx longi-

tudinally fifteen millimeters, but the ventral portion only three millimeters. The dorsal portion, when in ordinary use, shifts on the phalanx about seven millimeters,—just enough for its thickened portion to lie across the phalanx or over the joint.

When the sleeve is distalward down the back of the phalanx, the intrinsic muscles can flex the proximal finger joints, but when the sleeve is drawn proximalward by the action of the long extensor tendon, the sleeve is over the proximal joint itself, thus robbing the intrinsic muscles of their leverage on the phalanx for use in flexing. It is like the shifting of gears. At the same time the long extensor tendon, in shifting the aponeurosis proximally, stabilizes the proximal joint in extension. The pull of the intrinsic muscles then is made automatically on the other branch of the Y of its tendon—the lateral band—and by it extends the distal two finger joints or imparts lateral motion. The transverse fiber

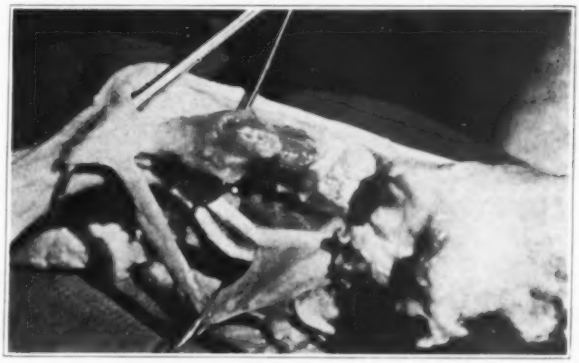

FIG. 7-A

Insertion of the lumbricalis and interosseus into the aponeurosis. A pull on either flexes the proximal joint by the transverse fibers which form a sling over the dorsum of the proximal phalanx.

FIG. 7-B

The lumbricalis is pulled.

FIG. 7-C

The interosseus is pulled.

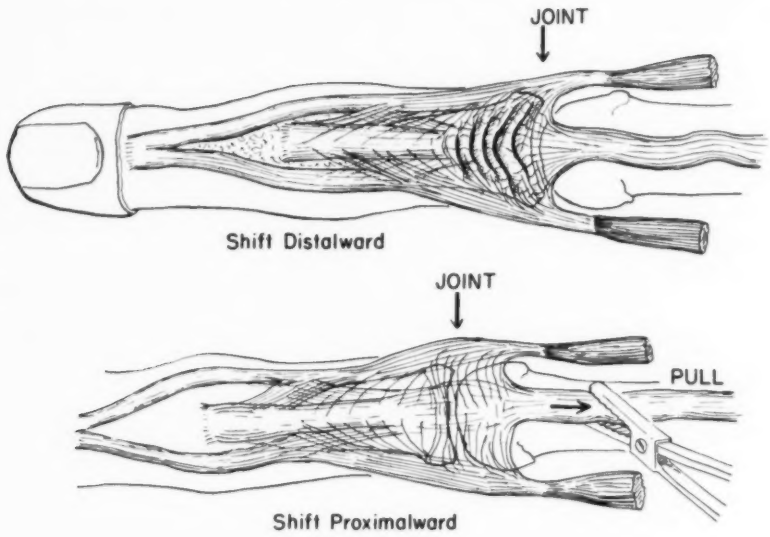

FIG. 8-A

The shift of the aponeurotic sleeve. Transverse fibers form a dorsal sling over the back of the proximal phalanx to flex the proximal joint, but when the extensor tendon, in stabilizing the proximal joint, shifts the sleeve backward until it is over the joint, the lumbricales and interossei pull on the lateral band to extend the distal two joints. (See Figs. 8-B and 8-C.)

branch of the Y slackens from the shift of the sleeve proximally. Therefore, when the long extensor stabilizes the proximal joint in extension, the intrinsic muscles extend the distal two joints. They flex the proximal joint only when the long extensor is relaxed.

Tendon Shift Volarward at Middle Finger Joint

The two lateral aponeurotic bands, which at the middle joint are in a rather dorsal position, are, as this joint flexes, seen to shift volarward one-fourth of the thickness of the finger, so as to short-cut this joint. This volar shift yields three millimeters of slack in the extensor tendon of the distal joint, which is important in repairing the insertion. Each main lateral band forks to spiral and lateral tendon slips to extend the middle and distal joints respectively, and has just eight to nine millimeters of motion to extend these two joints. On flexion of these joints, however, the lateral forks must short-cut across the middle joint, so that the above limited excursion of the main lateral band will allow both the middle and distal joints to be flexed at the same time. The shift conserves the longitudinal amplitude of the tendon bands and allows both joints to function.

Lumbricales

These four small muscles, named from their resemblance to a worm, have both origin and insertion on tendons of other muscles. Located on the radial sides of the digits, after arising by one or two heads from the profundus tendons, they lie between the tendons of the profundus and

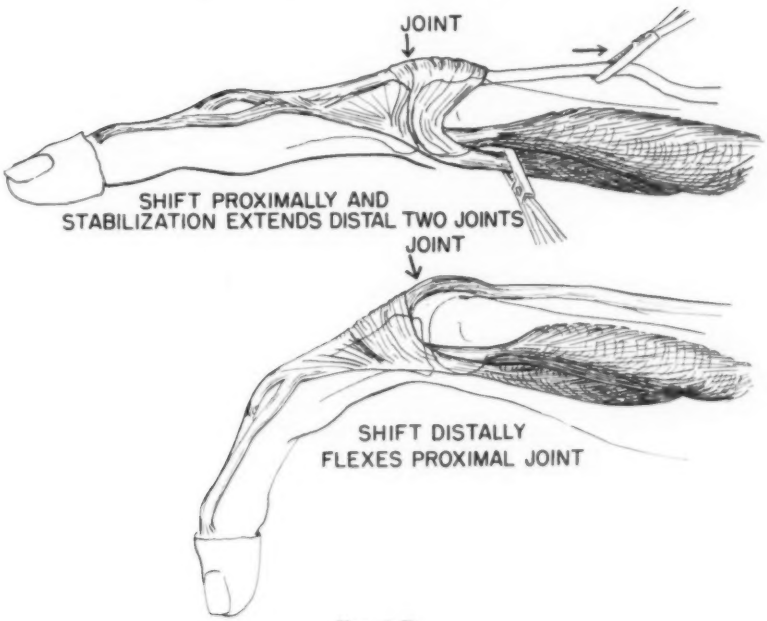

FIG. 8-B

sublimis, are flat, and each is intimately wrapped half around the sublimis tendon. They then diverge radialward from the sublimis and pass in front of the slippery flat transverse metacarpal ligament, which spans the distance between the heads of the metacarpals and lies in front of the interosseous spaces, separating the lumbricales from the interossei. The lumbricalis, in crossing the transverse metacarpal ligament, passes over the radial condyle of the metacarpal, and from there turns dorsalward to join the tendon of the interosseous just distal and lateral to that muscle, to form the outermost fibers of the lateral band or expansion of the dorsal aponeurosis, and also the

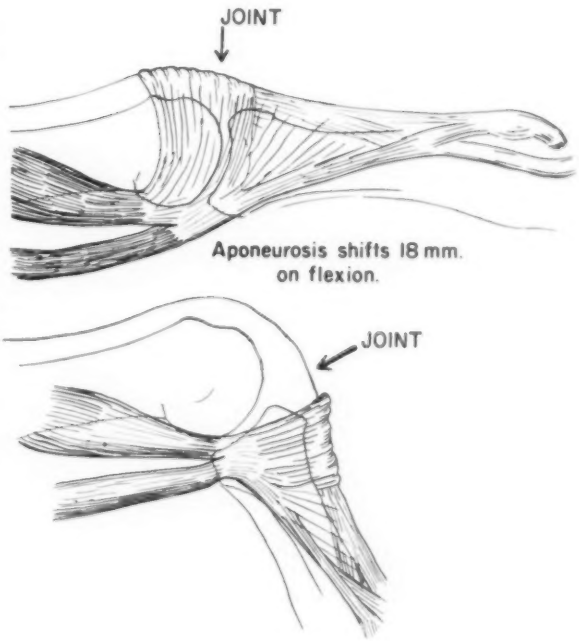

FIG. 8-C

FIG. 9-A

FIG. 9-B

transverse fibers which loop over the back of the phalanx.

In the turn dorsally, as it passes over the radial condyle of the metacarpal, the lumbricalis makes an angle of approach to the phalanx of 35 degrees for good flexion action.

When the long extensor tendon is taut, the lumbricalis extends the distal two finger joints and gives some radial lateral motion; but, when the long extensor tendon is slack, the lumbricalis flexes the proximal finger joint and nothing more. Lumbricalis action in extending the distal two finger joints is strong when the proximal joint is held fully extended, but lessens as this joint flexes through its first 45 degrees, or one-half of its range. Beyond this, lumbricalis action soon becomes nil, as this function is taken up by the long extensors.

The lumbricalis initiates flexion of the proximal finger joint, even when the latter is in hyperextension, and carries through its complete range of flexion. The long flexor tendons alone can also flex these joints strongly, as is seen in cases of median and ulnar palsy. The lumbricalis is dependent also on its origin from the flexor profundus tendon, and this must first be tense. A profundus tendon, also through the lumbricalis, flexes the proximal joint or aids in extending the distal two. In extending the fingers, the lumbricales aid, not only in extending the distal two joints, but also in drawing the profundi distalward to allow the fingers to extend freely.

Interossei

The four dorsal interossei abduct the fingers from the long finger as an axis, and the three palmar interossei adduct them toward the axis. The dorsal ones insert by separate slips to bone, capsule, and tendon, but the palmar ones insert mostly to tendon with an occasional slip to capsule. In man, most of the interossei have three different types of insertion: one

on the lateral tubercle of the phalanx, which is somewhat ventral to the mid-line; another by a small slip to the side of the joint capsule, which in turn is transmitted both dorsally, by some transverse fibers to the sling of the dorsal aponeurosis, and longitudinally, through the capsule to the side of the phalanx; and a third to the lateral band or expansion of the dorsal aponeurosis.

FIG. 9-C

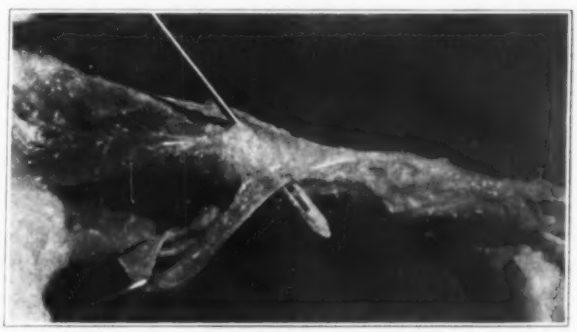

FIG. 9-D

Stabilization of the proximal joint in extension by the long extensor tendon pulls the aponeurotic sleeve proximally until it is over the joint (Fig. 9-A). The intrinsic muscles then pull on the lateral band and extend the distal two joints (Fig. 9-D). A shift of the aponeurotic sleeve distalward changes their function to flexors of the proximal joint (Figs. 9-B and 9-C). In Figs. 9-A and 9-B a probe marks the joint, and a hemostat on the aponeurosis shows the shift.

The first dorsal interosseus is unique in inserting into the lateral tubercle and into that part of the aponeurosis which transmits its pull to the transverse fibers only, but has practically no action of extension on the distal two joints. The interossei in the third cleft, and occasionally in the second cleft, may be devoid of insertion on the tubercle, but they usually send a slip to the joint capsule as already explained.

In a cleft, a typical arrangement of the dorsal interosseus is to have two bellies more or less fused, each of which takes its origin from each of the contiguous metacarpals. The superficial one runs volarward, crossing either radialward or ulnarward over the deep one to insert deeply either to the tubercle or capsule of the joint. The deeper belly inclines dorsally and inserts into the lateral band, sending a small slip to the capsule. This separates somewhat the functions of these two muscle bellies,—the one to the bone flexing and giving lateral motion to the proximal joint; and the other, in addition to this, giving extension of the distal two joints.

The function of all the interossei is to flex the proximal finger joints when the long extensor tendon is slack. When the long extensor tendon

stabilizes the proximal joint in extension by retracting the aponeurotic sleeve as previously described, the interossei furnish lateral motion to the fingers and, with the exception of the first dorsal one, also extend the distal two finger joints. The interossei thus have the same functions as the lumbricales, but they are stronger in all the motions. The lumbricales give weak lateral movement, but have the advantage of angle of approach in starting flexion. They also have a longer range of movement, counting the additional help of the flexor profundus.

The interossei give lateral motion by any of their insertions,—band, capsule, or tubercle; but that from the latter is slightly stronger. The interossei initiate flexion of the proximal finger joints all the way from the straight position to that of full flexion and, along with the lumbricales, add considerable strength to the grip. Weakness of grip is marked in ulnar paralysis.

Extension of the distal two finger joints by the interossei and lumbricales is strong when the proximal finger joints are straight or hyperextended, but, as they flex to near 45 degrees, the action of the interossei and lumbricales becomes less, and beyond 45 degrees it becomes negligible. During flexion of the proximal joint, the long extensor takes on more and more the duty of extending the distal two joints and its maximum action is reached when the proximal joint is three-fourths flexed; from that point it recedes, especially in the distal joint.

FIG. 10-A

FIG. 10-B

When the proximal joint is stabilized in extension by the long extensor tendon, the lumbricales and interossei impart lateral motion to the finger. In both Figs. 10-A and 10-B the long extensor is taut; in Fig. 10-A, the interosseus is relaxed and in Fig. 10-B it is pulled upon, imparting lateral motion.

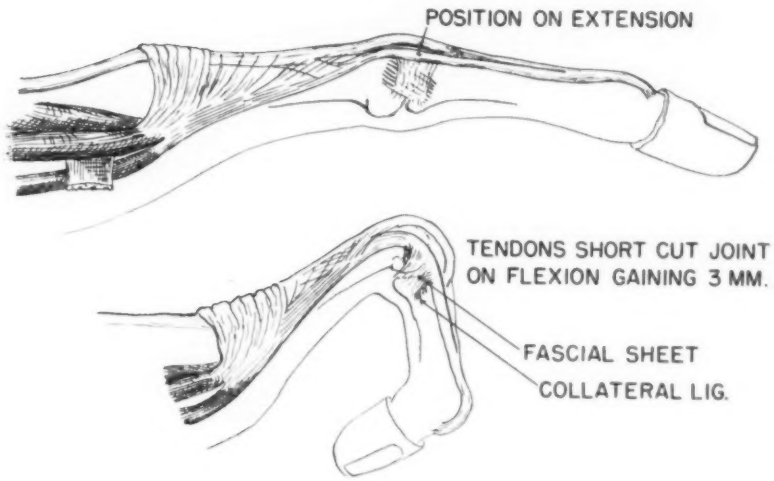

FIG. 11

The volar shift of the two lateral bands at the middle joint. On flexion the two lateral sheets automatically displace the tendons, so that they short-cut across the joint.

Long Extensor Tendon of the Finger

The long extensor tendon is synergic in action with the intrinsic muscles. Alone it extends the proximal finger joints to hyperextension. Extension of the distal two finger joints is by the intrinsic muscles or the long extensor, depending on the degree of flexion of the proximal finger joint as has been stated.

The long extensor tendon has the second important function of stabilizing the proximal finger joint in extension, so that only then can the intrinsic muscles extend the distal two finger joints and impart lateral motion to the finger.

The Adductors of the Thumb

In ulnar-nerve paralysis of the adductors of the thumb, two signs are of particular interest. The patient cannot make a perfect O with the thumb and index finger, and the pinch between them is weak. When he attempts to do this, the metacarpophalangeal joint of the thumb drops into hyperextension. The same deformity is seen from loss of the abductor pollicis tendon. In the former case it is due to lack of flexion effect on the metacarpophalangeal joint, and in the latter to loss of ability to stabilize the metacarpal in extension. Not all cases of ulnar paralysis show this, as in some the median motor nerve supply extends far enough ulnarward to flex the metacarpophalangeal joint.

Another sign of adductor paralysis is inability to scrape the extended thumb across the palm and bases of the fingers to the ulnar side of the hand. Instead the thumb comes forward from the palm at the radial border of the index finger.

FIG. 12-A

Shows the volar shift of the lateral bands on flexing the middle joint.

FIG. 12-B

Shows the resumption of the dorsal position of the bands on extension. A probe passes under the lateral sheet, which is attached to the collateral ligament and middle phalanx, and automatically causes the volar shift.

The abductor minimi digiti inserts on the lateral tubercle of the proximal phalanx and the joint capsule, and sends out transverse fibers and a lateral band like that of the interossei. It does not, however, extend the distal two joints. It flexes the proximal joint when the long extensor tendon is slack, and abducts it from the hand when the long extensor stabilizes the proximal joint in extension. The opponens minimi digiti opposes the little finger to some extent, similar to the opposition in the thumb. The thenar and hypothenar muscles, with the exception of the two abductors, maintain the carpal arches.

Carpal and Metacarpal Arches

The arching at the carpus and metacarpal heads is essential for grasping small round objects. It results in a tipping of the axes of the proximal finger joints, which makes the fingers converge on flexion and spread on extension, and greatly helps opposition of both the thumb and the little finger. The arches also give strength and resiliency when pressing with the hand. Normally, in opposing the thumb and little finger, the palm is cupped and the curve of the metacarpal arch is increased.

Maintenance of these arches is by the thenar and hypothenar muscles which span from the carpus to the two outside rays. Thus, in combined median and ulnar paralysis, the hand is flat and the thumb is at the side.

Movements of the Hand in General

Lateral movement of the fingers is possible only when the proximal joints are straight or nearly so. Absence of side motion when in flexion is desirable as it gives firmness to the grasp. When the joint is straight,

the proximal phalanx has free lateral motion on the narrow vertical saddle-like end of the metacarpal, and the collateral ligaments are loose. In flexion the phalanx slides volarward on an ever-widening articular surface. The collateral ligaments tighten, and, in full flexion, the flat end of the phalanx rests on the broad flat volar aspect of the head of the metacarpal, preventing all lateral movement.

One should not mistake the spread of the fingers, when in full extension by the long extensors, for action of intrinsic muscles, because this is due in part to the curve of the metacarpal arch, and, to some extent also, to muscle tension, aligning the phalanges with the metacarpals which diverge a little. Lateral movement by intrinsic muscles is possible only when the proximal joints are stabilized in extension by the long extensors. It should be tested by the individual lateral motion of the fingers when the proximal joints are in slight flexion. Strength and width of spread show it only when compared with that in the other hand.

The action of tendons and muscles in the hand can readily be checked by feeling one's own hand when the fingers are working against resistance. Thus one feels lateral bands, aponeurotic and volar shifts, long extensor tendons, lumbricales and profundus tendons in the various movements.

In normal muscle balance between the long extensors, long flexors, and the intrinsic muscles, the hand assumes a position with the wrist slightly dorsi and ulnar flexed, the fingers partially flexed in all joints, with increasing degree of flexion from the index to the little finger. The thumb is forward from the hand, partly flexed and in mild opposition, and the normal arches are present. In this position of function, the mechanics of the hand are at their best.

Every motion of the hand is done with balance of muscle pull or coordination between several muscles in synergic action. It has been seen how the work of extending a finger from full flexion falls first on the long extensor, but, as the extension progresses, is gradually taken over by the intrinsic muscles, the long extensor having changed to an extensor and stabilizer of the proximal joint. Practically it can be considered that the intrinsic muscles extend the distal two joints in the first half, or 45 degrees, of flexion of the proximal joint, and that the long extensor tendon extends them when the proximal joint is in the last half of the range of flexion, though, of course, transmission of function is gradual.

The separate functions of the intrinsic muscles are dependent on the stabilization of the proximal finger joints in extension by the long extensors. Without this they flex the proximal joints; with it they extend the distal two joints; and by pulling alternately they can give lateral motion.

The mechanism of volar shift of the two lateral extensor bands at the middle joint is effective in conserving the limited amplitude of the various muscles. The whole arrangement in the finger shows perfect synchronism, each muscle and tendon doing its part, conserving its limited amplitude of motion, and so relaying its action that, by coordination with each other, the complete motion is carried out.

CLINICAL TYPES OF LOSS OF INTRINSIC MUSCLES OF HAND

The long flexors can completely flex each of the three finger joints, but without the intrinsic hand muscles the finger tips in full flexion usually touch only the bases of the fingers, and are not flexed into the palm, the proximal joint remaining straight. There seems to be not enough amplitude of motion of the long flexor tendons to flex the proximal joints at the same time; help from the lumbricales and interossei is needed. Also, when the proximal joints are partially flexed by the long flexors, the distal two joints cannot be extended at the same time, as again the

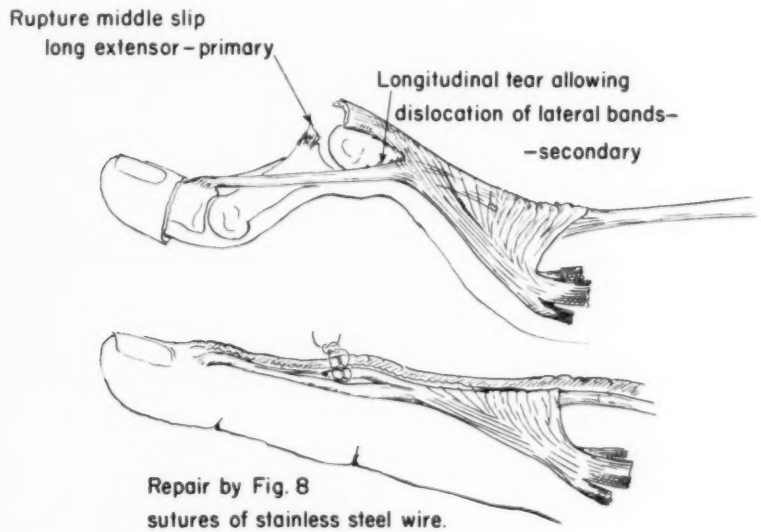

FIG. 13

The "*boutonnière*" deformity (top) is caused by rupture of the central extensor tendon slip at the middle joint and a subsequent tear of the aponeurosis. The lateral bands then flex the middle joint and extend the distal joint.

A simple figure-of-eight removable stitch of stainless-steel wire, together with splinting, is sufficient to cure a recent case. In a long-standing case, the slit also should be closed by a removable figure-of-eight suture through the skin and tendon.

intrinsic muscles are needed. Integrity of carpal and metacarpal arches and opposition of the thumb and little finger are wholly dependent on the thenar and hypothenar muscles with the negligible help of the palmaris longus. If the adductors of the thumb are not functioning, the thumb loses part of its range of motion across the hand and its force in adducting toward the hand. When lateral motion of a digit is lost, such as abduction of the index finger, the finger inclines ulnarward which upsets the mechanics for its good function.

When such imbalance remains, the unopposed strong muscles increase the deformity until it is structural—as is seen in long-standing cases of ulnar, or ulnar plus median, paralysis—necessitating correction of position before restoring muscle balance.

In ulnar paralysis, when repair of the nerve is no longer possible, there is need for restoration of carpal and metacarpal arches and of ability to adduct the thumb. Also the muscle balance should be restored to the little and ring fingers.

In combined ulnar and median paralysis, when it is not reparable by nerve suture, there is greater need for restoring carpal and metacarpal arches; all fingers are clawed and need return of muscle balance. The thumb is useless at the side of the hand and needs opposition and adduction. In poliomyelitis, the intrinsic muscles are often selectively paralyzed.

In the claw hand of Volkmann's ischaemic paralysis, the imbalance is from contracture overpull of the long flexors and also from a degree of paralysis of the intrinsic muscles. The latter is due to the ulnar nerve being affected by the ischaemia when in the fascial enclosure of the forearm, and by the subsequent strangling by cicatrix.

Hands that have been ravaged by infection show the same type of deformity that is seen in ulnar and median nerve paralysis (fingers clawed, hand flat, and thumb at the side), because during the infection the intrinsic muscles were paralyzed by being bathed in pus. Moreover, infection travels up the forearm along the course of the two nerves. Cicatricial strangling of muscles and nerves follows, and thus fixes the deformity of imbalance. Other cases for repair are those caused by direct injuries which destroy some of the intrinsic muscles of the hand or leave them immobile in cicatrix.

Rupture of the middle extensor slip near its insertion to the base of the middle phalanx results in the deformity of hyperextension of the proximal joint, flexion of the middle joint, and hyperextension of the distal joint. This "*boutonnière*" deformity has been ascribed to a central longitudinal tear in the extensor tendon, which allows the two lateral slips to separate and move volarward, so that the joint herniates through the slit. The lateral slips then act as flexors for the middle joint, thus increasing the deformity. This, however, is the result of first severing the middle slip. Then as the joint is flexed, the buttonhole tear occurs secondarily.

Two other deformities are common in fingers. One is drop-finger at the distal joint, due to bone evulsion or rupture of the extensor tendon insertion. This may be considered the insertion of the intrinsic muscles when the proximal joint is in extension, and of the long extensor tendon when it is well flexed.

Hyperextension of the middle joint with flexion of the distal joint occurs on rupture of the anterior part of the capsule of the middle joint. It also exists normally in some people, and in these the long extensor is seen to stand out as a strong double cord running to the middle joint and overextending it. The flexor profundus then automatically draws the distal joint into flexion. This occurs in double-jointed people with laxness of the anterior part of the capsule of the middle joint.

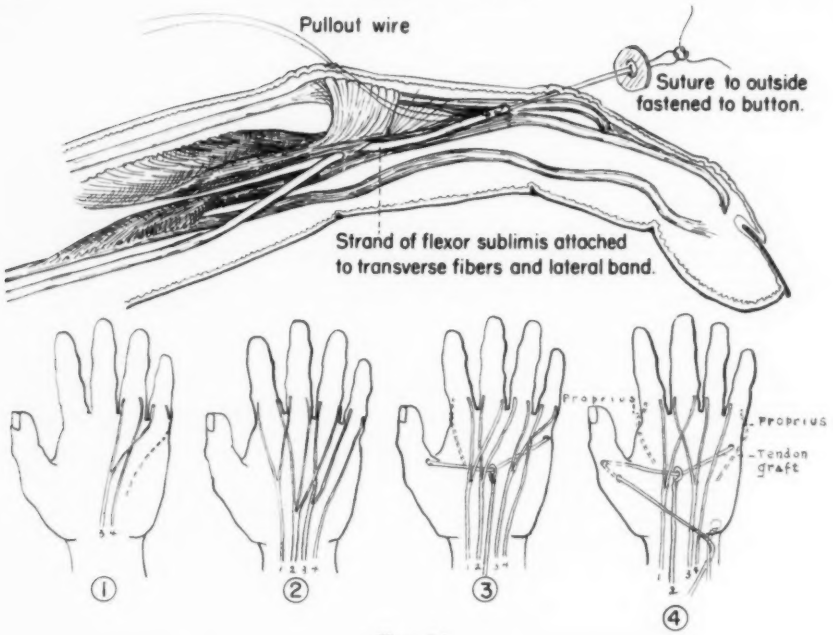

FIG. 14

In the operation to restore muscle balance in a finger after loss of the intrinsic muscles, the sublimis tendon, or a strip thereof, follows a straight course through the lumbricalis canal and is inserted into the transverse fibers and lateral band of the dorsal aponeurosis, by a simple stitch of stainless-steel wire No. 35 which passes on out through the skin to a button. The wire is removed by the pull-out wire in three weeks. The tendon and the dorsal surface of the lateral band have been scraped for better attachment. (*1*), (*2*), (*3*), and (*4*) show combinations for placing tendons, so that the lateral motion supplied by each single tendon to several fingers will be in the same direction. Small numbers indicate which sublimis tendon is used.

In (*3*) is shown a combination with a tendon-T operation for adduction of the thumb and restoration of the arches, and also an index long extensor used for abduction of the index finger. In (*4*) is shown the same with the addition of a tendon for opposition of the thumb and another for abduction of the little finger.

TREATMENT

Nerve suture for ulnar or median paralysis should be done if it is mechanically possible, and if the interval since the paralysis has not been so long that fibrous degeneration of muscle has been established to the point where even the reaction of degeneration is no longer present. The tiny motor branches of the ulnar and median nerves in the palm are not too small to suture with good results, as shown by eighteen personal cases. Operations for tendon transfer in such paralysis are only for patients in whom the nerve injury is irreparable. If the deformity is easily corrected passively, the nerve and muscles alone are to blame; but, if firm structural changes have set in, these must first be corrected by the usual methods of mild prolonged tension, capsulotomies, osteotomies, etc. Postinfection cases are not suitable for tendon transfer in a finger unless the tissues are flexible or unless by excision of cicatrix they can be made so.

The very thin and complicated dorsal aponeurosis is too delicate for the usual surgical repair by suture, and too readily adheres to the bone

beneath. Therefore, the author has been using the thinnest and least irritating suture,—stainless-steel wire. The simplest stitch is used and placed so that it can be removed in three weeks,—that is, withdrawn by a pull-out wire.

Sir Harold Stiles, in 1922, described an operation for claw-finger. He detached the flexor sublimis tendon from its insertion in the finger, split it, bringing each end around to the back of the finger and then suturing each to the extensor tendon with linen. He stated that he did not know the result as he was, due to the war, unable to follow the patients. The author tried this operation twice, but each time it resulted in failure, as the finger had less movement than before. The delicate parts of the extensor tendon were not differentiated and all became bound firmly. The suturing should not have been to the extensor tendon. Also, the sublimis tendon had a tortuous course and penetrated through an annular band of fascia, which favored adhesions. This operation does not consider the action on the transverse fibers and lateral band or the shift of the aponeurotic sleeve.

The following is a new technique which is planned to give the least possible adhesions, a straight course for the tendon, good leverage, and the normal angle of approach. The tendon juncture is made on the dorsal surface of the transverse fibers and the lateral band, where adhesions are not detrimental. The gliding surface of the lateral band and dorsal aponeurosis is not disturbed. There is no permanent suture material left in the wound.

In this operation the flexor sublimis tendons are detached from their insertions, withdrawn from the palm, split, and then passed down the lumbrical canals to be attached to the transverse fibers and lateral bands in the finger. The object is to restore muscle balance, to furnish extension to the distal two joints, to help flexion of the proximal joints, and to furnish lateral motion to the fingers. The middle joint is already in flexion deformity, so the loss of the sublimis is of less importance.

Through a mid-lateral incision in the finger, the length of the proximal segment, the sublimis tendon is cut off through a nick in the sheath opposite the joint. If cut too long, the stumps attach, making flexion contracture of the middle joint. The tendon is withdrawn enough to slit it an inch or more, and then, through an L-shaped incision in the palm paralleling the creases, is withdrawn and split its length. If desired, it may be split in four with the back of a scalpel blade.

A fine No. 35 stainless-steel wire with a needle on each end is sewed into the end of a strand of sublimis tendon, threading each needle back and forth twice through the tendon until the end of the tendon is reached, where the two ends of the wire will emerge. A pull-out wire is placed through the loop of the wire for later removal. The two end wires are threaded on one needle, which is passed down the lumbrical canal and on out the lateral incision in the finger and over the lateral band, the top surface of which is scraped to receive it. The wires are then passed on

across the finger and out through the dorsal skin, where they are fastened to a button. The two ends of the pull-out wire are threaded on one needle and passed out through the skin proximally, where they are left for use in pulling out the stitch three weeks later. To remove the stitch the ends are cut off close to the skin and the stitch is withdrawn backward by the pull-out wire.

From the one lumbrical canal two tendon strands will pass one to each side of the cleft. The bed of the tendon is in soft gliding tissue all the way. The tendon should be threaded in and out the aponeurosis once as it passes the transverse fibers, so that, by taking advantage of the gliding aponeurosis, it will both flex the proximal finger joint and extend the distal two. Attachment to the transverse fibers and lateral band will result if their contiguous surfaces are well scraped and they lie in close apposition while healing. The tendon will be found to be the right length, reaching to within a centimeter of the middle joint on the dorsum of the finger.

The split strands from any one tendon should go either all to the radial sides of the fingers or all to the ulnar sides, so that lateral motion will be possible, one tendon pulling two or more fingers radialward and another tendon ulnarward.

One must plan to use to the best advantage whatever tendons are available. If all sublimi, except that of the little finger which is tiny, are split in two, there are seven strands; some can be subdivided. Each finger should have at least one strand, so that the distal two joints will extend and the proximal joint will flex well. To the index and little fingers the tendon should be placed on the radial and ulnar sides, respectively, for abduction from the hand. Their respective extensor proprius tendons can be used for this purpose if desired. The sublimis tendon to the index finger should go to the lateral band instead of to the tubercle, if it is expected to extend the distal two joints. It is advisable to transfer tendons to each side of each finger, but one must figure to have enough tendons for also furnishing adduction and perhaps opposition to the thumb. Besides the sublimus tendons there are available the two extensor proprius tendons, the palmaris longus, and even free tendon grafts from the palmaris longus or extensors of the small toes. The hand and fingers are splinted for three weeks with the wrist in flexion. This is followed by light motion for another week and the refraining from hard work for two months.

Operations to Restore Adduction to the Thumb and Curvature to the Carpal and Metacarpal Arches

Two methods are available,—the tendon-loop operation and the tendon-T operation.

In the tendon-loop operation, to furnish adduction to the thumb, the tendon of the extensor digitorum communis to the index finger is detached, just before it spreads out over the proximal joint of the index finger, and is withdrawn at the base of the back of the hand. It is elongated, by

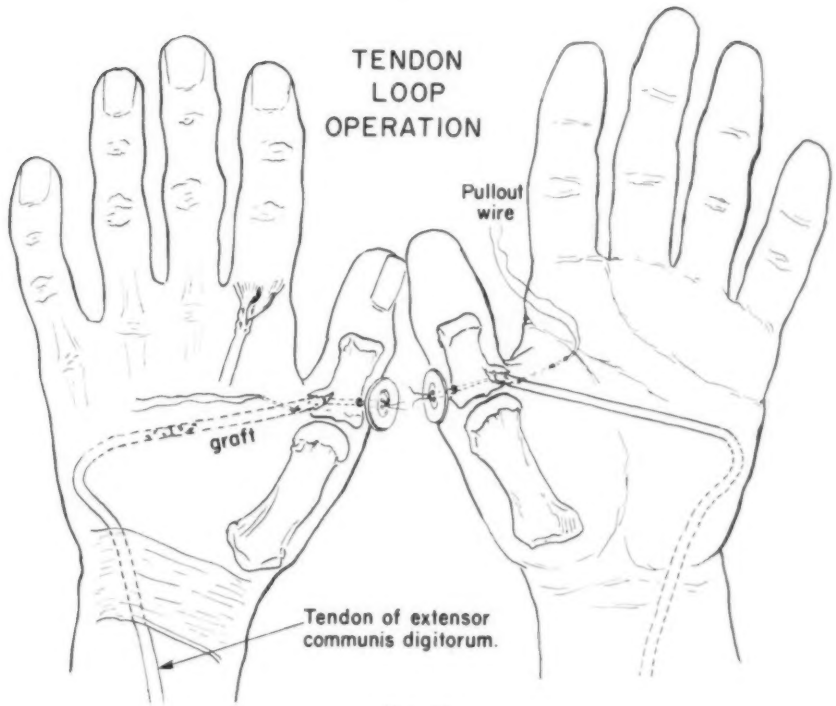

FIG. 15

In the tendon-loop operation to restore adduction to the thumb, the extensor communis tendon from the index finger is prolonged with a tendon graft, and then passed subcutaneously around the ulnar border of the hand and across the palm under the flexor tendons to act as an adductor of the thumb. Attachment to the thumb is by fine stainless-steel wire through a drill hole to a button outside the skin. A flake of bone is chipped up at the insertion. A pull-out wire is placed so that the stitch may be removed in three weeks. The stump of the extensor communis of the index finger is attached to the extensor indicis proprius to prevent rotation deformity.

adding a free tendon graft from the palmaris longus or other tendon, and is passed subcutaneously around the ulnar border of the hand, then across the palm deep to the flexor tendons, to be inserted on the ulnar side of the base of the proximal phalanx of the thumb.

The communis tendon is selected instead of the proprius, because its muscle is stronger. It is essential to attach its stump, where cut off, to the proprius tendon, so that the latter will pull symmetrically on the tendinous cap of the joint; otherwise the index finger will show deformity of rotation and adduction. A short transverse incision is used there and also on the dorsum of the hand at the distal edge of the annular ligament. The incisions at the ulnar border of the hand and ulnar side of the thumb are mid-lateral.

In passing the tendon around the ulnar side of the hand, it was found best not to pass it under the hypothenar muscles, because their perimysium adhered to it. A simple way of attaching the tendon to the phalanx of the thumb is to place a wire stitch in the tendon, as described

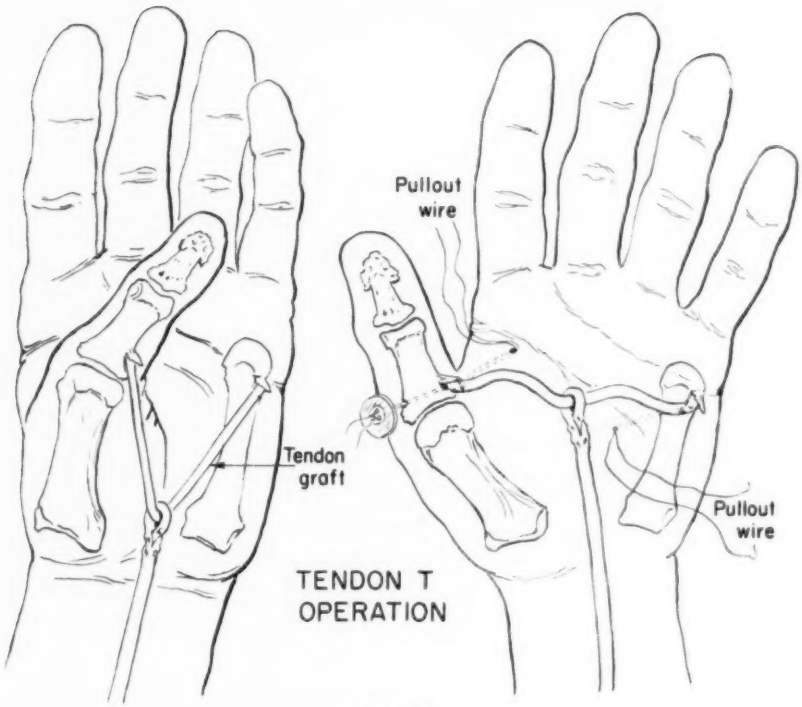

FIG. 16

In the tendon-T operation to restore adduction to the thumb and curvature to carpal and metacarpal arches, a tendon graft spans the distance between the little finger metacarpal and the adductor insertion in the proximal phalanx of the thumb. A long flexor tendon of the forearm (a sublimis or the palmaris longus prolonged by a strip of its palmar fascia) is looped over its center to form the T. This, when in action, changes to a Y adducting the thumb and curving the arches. Attachments to bone are made as in Fig. 15.

in the operation for claw-finger. A thin flake of bone is chipped up, and under this the wires on a single straight needle are passed through a drill hole through the bone and out the skin on the opposite side of the thumb, where they are threaded through the holes of a button and tied. The pull-out wire is also brought out through the skin proximally, so that the stitch wire may be removed in three weeks.

The tendon-T operation gives strong adduction to the thumb and little finger and cups the hand, restoring carpal and metacarpal arches. It consists of one free tendon graft spanning across the palm behind the flexor tendons from the base of the proximal phalanx of the thumb to the neck of the metacarpal of the little finger. One of the long flexor tendons of the forearm, such as a sublimis, is attached by a loop to the center of the cross tendon, thus forming a T. On flexion of the muscle, the T is drawn to a Y, drawing the thumb and fifth metacarpal toward each other and restoring the arches. The cross member lies in soft movable tissue back of the profundus tendons and can be drawn proximalward without resistance. It does not press or pull against the deep branch of the ulnar

nerve which is behind it. The cross part of the T comes in full flexion as far proximally as the carpus, and the angle of the Y thus formed is then 40 degrees.

The fifth metacarpal is exposed in its ulnar volar aspect. One end of the cross tendon is fastened to it under a chipped-up flake of bone, as described for the thumb in the tendon-loop operation, the button resting on the skin of the back of the hand over the dorsoradial aspect of the fifth metacarpal, where the wires come through. The palm is opened by a small L-shaped incision paralleling the creases. The tendon is passed across through the palm behind the flexor tendons, and is made to emerge through a small lateral incision over the ulnar aspect of the base of the proximal phalanx of the thumb. Here it is similarly attached by passing the wires through the phalanx and thumb to a button on the opposite side, and placing a pull-out wire. The tendon should be slack when the hand is fully spread, as grafts shrink a little. The long flexor tendon is then looped around the center of the cross tendon, embedding it in and suturing it to itself; one stitch is placed to keep it from sliding along the cross tendon. In place of the sublimis tendon, the palmaris longus tendon with its prolongation of palmar fascia, or any other flexor tendon that is available, may be used.

Operation to Furnish Abduction to the Index Finger

Frequently from local injury there is loss of the first dorsal interosseus muscle with adduction deformity of the index finger, which greatly interferes with its function. In such a case the extensor indicis proprius is detached near its insertion and, after it has been lengthened with a short tendon graft, it is inserted into the lateral tubercle on the radial side of the proximal phalanx of the index finger. The stub of the insertion of the proprius should then be sutured to the extensor communis tendon of the index finger, so that the latter will pull symmetrically on the tendinous cap over the proximal joint of the index finger. In ulnar paralysis only a little adduction of the index finger occurs, as there is no functioning muscle to cause the deformity.

In case of loss of the index finger and its metacarpal, the long finger may go into adduction and need this operation. Similarly, abduction can be supplied to the little finger after loss of its abductor by using the extensor digitiquinti proprius.

If an interosseus tendon is merely adherent to the bone from injury, a piece of deep fascia, if placed between tendon and bone with its gliding side outward, will allow movement. Cicatrix, if present over the site, should be replaced with a good flap of skin.

Repair of Drop-Finger

If splint treatment is commenced within a week and maintained for five weeks, operation can usually be avoided. The middle finger joint should be in flexion and the distal joint in extension, as this is the effective

position for relaxing the tendon. Flexion of the middle joint gains three millimeters of slack in the tendon. Operation does not always result in motion. From the reaction of a silk suture, the tendon often adheres to the dorsum of the head of the middle phalanx. Better results were obtained by placing a fine stainless-steel-wire stitch in the tendon, with a pull-out wire for removal in three weeks. A spot for insertion on the distal phalanx is then roughened and the tendon end is held there by passing the wires on out through the skin and tying them through a drill hole in the finger nail. Great care is used to minimize trauma. Bivalved plaster splinting in the position described and including the hand is maintained for a month.

For drop-finger at the middle joint, two figure-of-eight stitches of fine stainless-steel wire, No. 35, are placed through tendon ends and skin, and an extension splint is applied. The longitudinal tear, allowing the tendon strands to separate, will then heal by itself if recent. If the tear is old, it is freshened and sutured by a figure-of-eight fine wire, which is carried out through the skin.

SUMMARY AND CONCLUSIONS

1. The intrinsic muscles of the hand are primordial, having started in the fish. The hand developed before the arm. Intrinsic muscles persisted down the animal phila and not until later did some intrinsic hand muscles develop into the long flexors and extensors (flexor profundus in reptiles and flexor sublimis and extensor brevis in mammals).

2. The interosseus and lumbricalis muscles have two separate functions, depending on whether or not the proximal finger joint is stabilized in extension by the long extensor tendon,—(1) extension of the distal two joints of the fingers together with lateral motions of the finger, and (2) flexion of the proximal finger joints.

3. A shift of the aponeurotic sleeve at the base of the finger aids in determining these movements, and a volar shift of lateral bands at the middle joint makes normal movement possible.

4. In the first half of the range of flexion of the proximal finger joints, the intrinsic muscles predominate in extending the distal two finger joints, but in the last half of flexion, the long extensors predominate.

5. Normal finger action depends on nice muscle balance, coordination, and synergy,—each of the various intrinsic and long muscles and tendons doing its part in the consecutive motion.

6. There are different types of deformities due to loss of action of various intrinsic muscles.

7. For loss of intrinsic-muscle action various methods of operative treatment are valuable in restoring muscle balance to the fingers and adduction to the thumb, and in restoring the carpal and metacarpal arches.

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   [Note: In this paper, on page 281, line 3, and on page 282, line 31, the words "flexor pollicis brevis" should be substituted for the words "extensor carpi radialis".]
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THE INFLUENCE OF ESTROGENS ON THE SHAPE OF LONG BONES

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The growth or enlargement of long bones is always accompanied by a certain amount of bone destruction. Duhamel, in 1739, proved that the expansion of the marrow cavity during the widening of the shaft was due, not to the interstitial growth of the cortex, but to external apposition and internal dissolution, for metal rings placed around the periosteum in young pigeons were later recovered from the marrow cavity. A few years later John Hunter pointed out that the slenderness of the shaft of a bone, as compared with the breadth of the epiphysis from which it developed, could only be explained by the local resorption of the bone at the outer surface of the subepiphyseal region during growth. More than a century later Kölliker, in 1873, charted the location of this active resorption on the surfaces of many bones at various ages, as marked by the presence of Howship's lacunae and osteoclasts. The present paper deals with a further analysis of this subepiphyseal resorption of the surface of the diaphysis, to which in great part is due the adult shape of long bones, and suggests probable causes for the phenomenon.

The external or surface resorption is a much more rapid, vigorous process than that entailed in the widening of the marrow cavity. In the latter case, the depth of the erosion, as represented by the increase in the diameter of the cavity, may be measured by a few millimeters in a score or so of years. The external resorption or etching, if properly analyzed, is relatively much more extensive, for the erosion does not proceed inward toward the bone center, but in a linear, axial direction, and is measured by the increasing length of the bone. This is shown by study of the subepiphyseal region where the etching is going on (Fig. 1-*1*). As is well known, the cartilage cells at the epiphyseal line multiply, become arranged in vertical rows, and degenerate. Their lacunae enlarge at the expense of the cartilage matrix and run together, until only irregular spicules or trabeculae remain, which become coated by bone matrix by the entering periosteal tissue. It is these vertically oriented bone trabeculae at certain surfaces of the bone circumference that undergo resorption at their free tips, so that, as they elongate at one end at the expense of the cartilage, they are curtailed at the other or proximal end by destruction of their bone matrix. The destruction is most active at the periphery of the bone, for the trabeculae are successively longer toward the center of the shaft, their tips forming a smoothly sweeping curve, until a region is reached where bone destruction is absent and the trabeculae become incorporated in the shaft. The general effect is noticed as the undercutting of the epiphysis and as the local erosion of the shaft, which thus becomes more slender, though again by a matter of only a few millimeters; the actual

bone destruction is at right angles to this apparent direction, and is as rapid as the epiphyseal bone growth, which may amount to many centimeters during the growth period.

Histologically the changes accompanying the slow form of bone destruction are quite inconspicuous, but in the more vigorous type the cellular picture is characteristic. This has been given elsewhere[1], where it was pointed out that the erosion of the trabeculae and the coincident inrush of young connective tissue into the enlarged primary marrow spaces are so similar to the changes found in the pathological entity known as osteitis fibrosa, that one may consider them as a minimal stage of this disease. Conversely, since this etching or undercutting is normally present in growing bones, one is forced to the conclusion that this form of osteitis is not due to an abnormal process, but merely to the abnormal increase of a process, itself normal to a minute degree during bone growth, and that the causative factor in the undercutting is probably the same as that underlying the disease.

Osteitis fibrosa, with the increase of serum calcium which accompanies it in its well-developed form but is not measurable in its early stages, is now known to result from hyperparathyroidism. Of this many clinical observations and the experimental production of the typical bone lesions in animals[5] have supplied sufficient proof. The parathyroid glands are commonly spoken of rather vaguely as the "regulators" of calcium storage in the bone, and, by implication, also of the extent or severity of the destructive process which sets the calcium free. The idea of regulation connotes either the ability to measure the supply of the activating principle—whether it is to be more or less—or the control afforded by two opposing principles, working in this case for bone deposition and bone resorption respectively. For either purpose the parathyroid glands seem peculiarly ill-adapted. Unlike the thyroid gland where partial removal reduces correspondingly the hormonal output, the parathyroid glands can be reduced in number with no noticeable effect on the general metabolism, showing that their product is not well regulated quantitatively; and far from containing a variety of cell types able to secrete hormones known to have different actions, as is the case with the hypophysis and some other endocrine organs, the parathyroid glands have but one type of cell in different phases of activity[7], and only one product, parathormone, is recognized. While there is abundant proof that hyperparathyroidism results in the bone changes characteristic of osteitis fibrosa, the normal parathyroid glands are not equipped as "regulators" for the balance called for in the modeling of growing bones.

Another agent which is now recognized as able to induce osteitis fibrosa is the female hormone, theelin. Bremer in 1941 noted that the description of its action given by Silberberg and Silberberg in 1938 almost parallels that of Burrows in the same year concerning the effect of parathormone. In the search for an agent better suited than is parathormone

to control the undercutting, and thus regulate the future shape of the bone, the author treated a series of young rats with theelin. The extent of the increase in bone resorption which may be attained in a rat by the injection of this hormone for a few weeks can be measured by comparison with the normal bone (Figs. 1-*1* and 1-*2*). In contrast to the normal bone, the erosion in the theelin-treated bone is much greater. The trabeculae

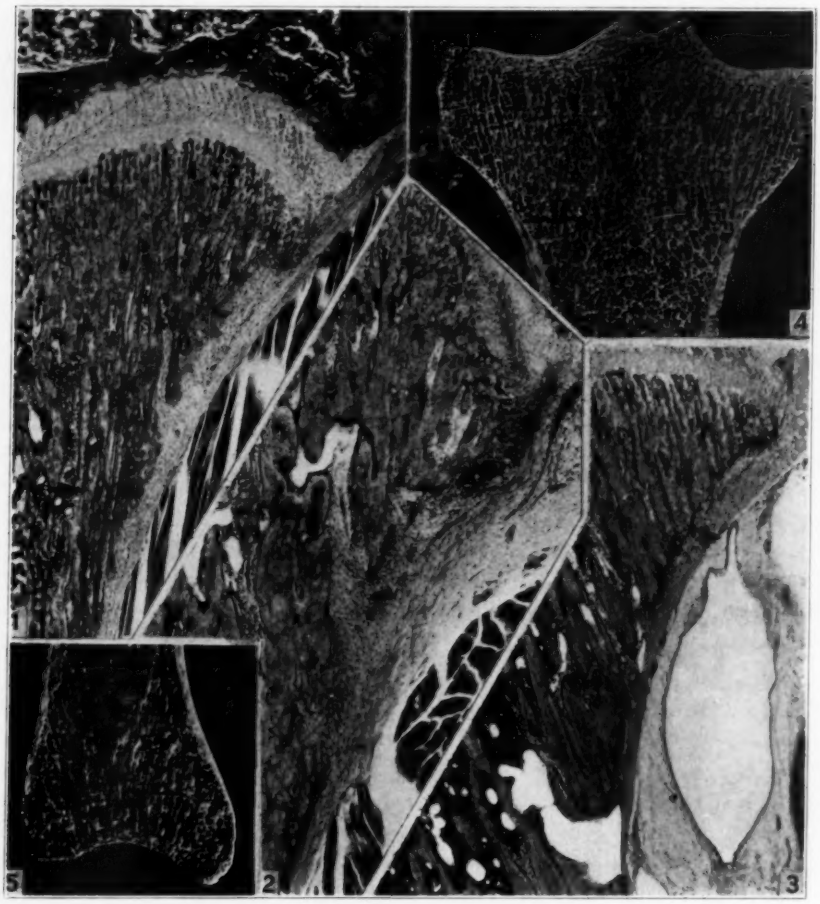

FIG. 1

Fig. 1-*1:* Photomicrograph (× 40) of a sagittal section of the tibia, including the proximal epiphyseal line, of a normal rat forty-seven days old, shows widespread moderate destruction of bone trabeculae.

Fig. 1-*2:* Photomicrograph (× 40) of a sagittal section of the tibia of a rat fifty days old, after 4500 international units of theelin had been given in twenty-one days. Note the increase of bone destruction and fibrosis.

Fig. 1-*3:* Photomicrograph (× 40) of a sagittal section of the tibia of a rat fifty-four days old, after forty-five milligrams of oretone had been given in thirty days. Note diminution of destruction and smooth contour of bone.

Fig. 1-*4:* Photograph of a frontal section of the proximal end of a human tibia. (*Reproduced from Triepel* [13].)

Fig. 1-*5:* Photograph of a frontal section of the distal end of a human tibia. (*Reproduced from Triepel* [13].)

are more massive, as often occurs, for the whole process of bone-building and bone-shaping has been intensified by the treatment, but the most significant change is the more rapid erosion of some of the trabecular tips and the deep, widespread invasion by mesenchymal tissue of the enlarged marrow cavities. This resembles osteitis fibrosa, but in a minor degree. For the problem at hand, the important point is that theelin can increase the normal erosion at the surface of the bone, which thus shows a deeper, more irregular etching.

For theelin and other estrogens an antagonistic principle is ready at hand. All bodies, of either sex, contain a supply of both estrogens and androgens. Their antagonistic action is well known in many organs, and in 1938 was proved specifically for bone by Gardner and Pfeiffer who showed that the effects to be expected following the injection of theelin could be suppressed by the subsequent injection of testosterone. In the present series, with the idea that theelin was always normally present, testosterone was given to normal rats. Comparison of these bones (Fig. 1–*3*) with the normal shows a definite reduction in the erosion, as indicated by the shallower indentation and the smoother contour of the bone. This gives another proof that the normal erosion is caused by the presence of theelin, though in both cases it is quite possible that the sex hormone acts through the medium of the parathyroid glands. If excess of theelin results in an increase of the etching process, and excess of testosterone in its inhibition, it seems reasonable to assign to these two hormones, and not to that of the parathyroid glands, the röle of regulator for the shaping of the bones, and to assume that a proper balance between them is the condition requisite for the production of normal forms.

As for the choice of the specific locations of the areas of bone resorption on the surface of any bone, the author has only suggestions to offer. It is known that resorption attacks by preference the youngest, most recently formed matrix; this would account for its occurrence in the subepiphyseal region, but not for its limitation to the periphery of this region and to only certain portions of this periphery. Stockard in 1921 asked the question: "If the internal secretions in the blood produce these peculiar growths, why do they not always act on all similarly growing parts in a similar manner?" The answer may lie in the position and the permeability of the regional veins. It has been shown that for dyes of certain grades of diffusibility, the cutaneous venules are the most permeable part of the vascular tree[10],—perhaps because of their thin walls and the slowness of the current. In the neighborhood of the epiphyseal line, the vascular tree shows veins with walls composed only of endothelium, which grow larger as they approach the surface of the bone and assume additional coats only in their passage through the periosteum. Their exit is marked in the adult by an incomplete circle of perforations just below the epiphyseal line[4]. In the present series of bones of young growing animals, they seem to predominate in the areas of deepest etching. Röhlich finds similar thin-walled veins at the margin of the marrow cavity of the shaft, a

region marked even in the adult by evidences of slow resorption. If the escape of the hormone from the vessels simulates the diffusion of dyes (of which there is no present knowledge), the special resorptive activity in these regions becomes understandable. This offers a theory worthy of due consideration.

The mention of androgens and estrogens suggests inevitably the differences between the two sexes. There is a general feeling that female bones are more delicately molded than male. Anthropologists, however, hesitate to give too much weight to such differences. Given the whole skeleton, or the pelvis, or to a lesser degree the skull, identification can be made with some assurance; but, if only single long bones are available, the problem is much more difficult. It is true that female bones cease their growth at an earlier age than male [12], but size is no criterion in the adult. The greater musculature in the male causes more rugged surface markings, but the variables are so great that little weight can be given to these characteristics. One characteristic is considered fairly dependable,—the depth of the bone fossae is greater in the female in 60 to 65 per cent. of all cases. This agrees with the major premise of the present paper, for the presumable preponderance of estrogens in the female would be reflected in the greater erosion of subepiphyseal bone.

One other, only slightly related, consideration of some interest to clinicians is brought out in this study. The internal architecture of adult bone is usually considered the result of the rearrangement of the cancellated portion, so that the trabeculae come to lie in the proper orientation to withstand stress or strain. This is undoubtedly true as a general rule, but the two photographs (Figs. 1-*4* and 1-*5*) reproduced here from Triepel's monograph show that rearrangement does not always occur. The closed epiphyseal plate can be recognized crossing the bone horizontally, and, at the upper end of the tibia, turning slightly downward as it nears the periphery. The diaphyseal trabeculae dependent from it at practically right angles here slant inward, being oriented by the vertical rows of cartilage cells which were present before the closure of the plate, as is shown by comparison with the young rat bones. The trabeculae meet the thin cortical plate, which is absent in younger stages and only develops when growth ceases, at acute angles sufficiently narrow to be considered an adaptation for the purpose of distributing the weight. At the lower end of the tibia, on the other hand (Fig. 1-*5*), the edges of the epiphyseal plate turn toward the joint, away from the diaphysis, and the trabeculae meet the cortex at a much less advantageous angle. Their orientation has been determined by the rows of cartilage cells; there has been no adaptation for service. It seems that these peripheral trabeculae, which during the modeling of the bone have suffered continual erosion and borne no weight, are incorporated into the system without change and only by chance sometimes fit the general architectural scheme. Where this does not take place, the bone is especially liable to fracture.

SUMMARY

The shape of long bones is governed to a certain degree by the extent of the surface erosion in the subepiphyseal region. The erosion shows the characteristics of osteitis fibrosa, and may be considered as similar to the initial stage of this disease. The disease may be caused by hyperparathyroidism, but the parathyroid glands are shown to be ill-adapted for the rôle of "regulators" of normal bone growth. The erosion can also be increased by theelin, and inhibited by testosterone. The balance between these two antagonistic principles probably regulates the intensity of the bone etching and maintains normal control of bone shapes. The greater depth of the fossae often recognizable in female bones may be due to an excess of estrogens. It is suggested that the location of the areas of erosion is determined by the position of the thin-walled veins of the subepiphyseal region.

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FEMORO-ISCHIAL TRANSPLANTATION *

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It has been generally recognized that in tuberculosis of the hip joint, where the head and neck of the femur have been extensively destroyed, the standard methods for securing ankylosis are either impossible to carry out, or the results are too poor to warrant their use. At Sea View Hospital a number of such problems have always been present in the past. These patients were noted in a review of those for whom rehabilitation had not been possible. Recognizing the close approximation between the adducted femoral shaft and the tuberosity of the ischium, it was believed that severance of the femoral shaft and transplantation of its sharpened end to the ischium would result in a high percentage of synostoses. It was reasoned that the ischium has great osteogenetic properties (as seen after fracture), and that the end of the femur, with the marrow cavity exposed after being severed at a level below the sclerosis caused by tuberculosis, might likewise have great osteogenetic properties. The matter was considered for some time, and finally in December 1936 a femoro-

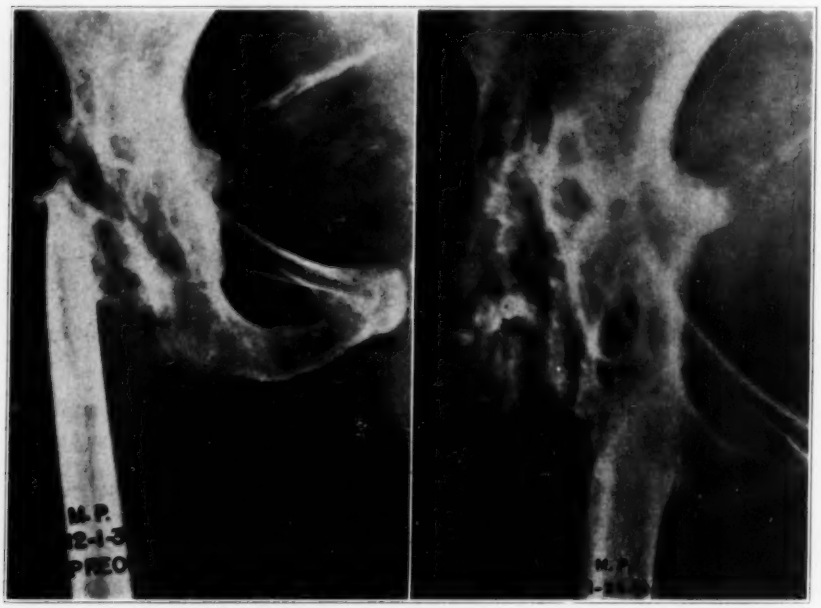

FIG. 1-A FIG. 1-B

M. P. Proved tuberculosis of the hip of fifty years' duration. Patient had been operated upon twenty-three times.

Fig. 1-A: December 1, 1936. Preoperative roentgenogram.

Fig. 1-B: January 25, 1939. Solid weight-bearing union was secured by femoro-ischial transplantation in one stage.

* Read before the Annual Meeting of the American Orthopaedic Association, at Toronto, Ontario, June 12, 1941.

ischial transplantation was performed on the first patient. Since that time eight more operations for femoro-ischial transplantation have been performed.

STATISTICAL DATA

In spite of the difficulty of securing tuberculous tissue in old burned-out lesions, the organism was definitely proved by section or smear in seven of the nine patients operated upon. One of the two patients whose hip was not proved to be tuberculous had a proved tuberculous knee joint, and the other had chronic lung tuberculosis. The age range was from twelve to fifty-two years, with an average of thirty years. Two patients were colored and seven were white. There were six "Americans", one Irishman, one Slav, and one Italian. In six patients the right hip was involved and in three, the left. Neither compensation nor lawsuit was a factor in any case. The average duration of the disease was twenty years. The onset in all but two instances was in early childhood. Complete disability for bearing weight without crutches, brace, or other support had been present in each instance for most of the duration of the disease. Many operations had been carried out on these patients. In four instances sinuses had been continuously present throughout the

FIG. 1-C FIG. 1-D

M. P. Gross specimen of synostosed femoro-ischial transplantation, secured at autopsy over two years after weight-bearing. Death was due to a renal lesion and peritonitis. There was solid ankylosis in good position.

course of the disease,—in one patient for fifty years. The presence of sinuses necessitated the operation being performed in two stages in three instances. Of the three treated in this way, spontaneous ankylosis with continuing sinuses occurred in one; failure of ankylosis with continuing sinuses, in one; and in one healing was secured and second-stage femoro-ischial transplantation was performed without reopening the sinuses. Two of these three have been rehabilitated with regard to their hip lesion. In no patient has sinus formation developed postoperatively when sinuses were not present at the time of operation. All but one of the patients had grade-four destruction of the hip joint, and this one had had a complete dislocation for many years. The amount of preoperative shortening varied from two to seven inches. In two of the patients, in whom synostosis was secured, no length was gained or lost, but in others gain in length was secured,—in one instance to the amount of two inches. All patients showed considerable atrophy of the thigh, which in most patients was in a markedly adducted position. All patients except one

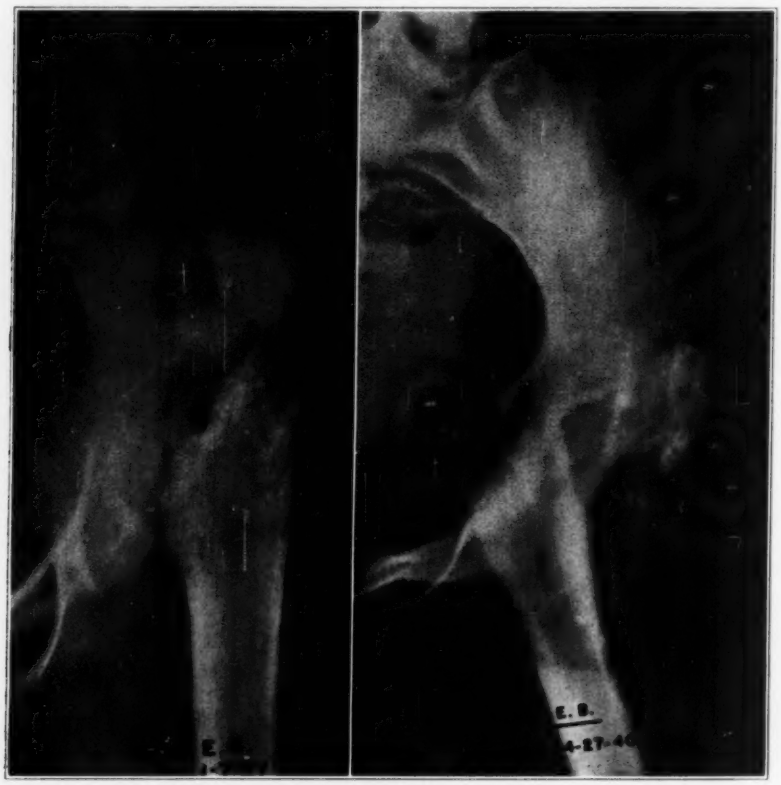

FIG. 2-A FIG. 2-B

E. B. Proved tuberculosis of the hip of sixteen years' duration in a patient twenty-one years old. A routine attempt at fusion had failed.
Fig. 2-A: January 7, 1937. Preoperative roentgenogram.
Fig. 2-B: April 27, 1940. A femoro-ischial transplantation in one stage resulted in weight-bearing in eight months.

FIG. 3-A FIG. 3-B

L. F. Proved tuberculosis of the hip of fourteen years' duration in a seventeen-year-old patient.
Fig. 3-A: October 25, 1938. Preoperative roentgenogram.
Fig. 3-B: February 18, 1941. A femoro-ischial transplantation in one stage was successful for weight-bearing in six months.

appeared in fair general condition; in that one steady down-grade progress necessitated some form of ankylosis. Steady improvement occurred following ankylosis. Though the patients appeared in good general condition, the prognosis, when rated on the basis described by Cleveland [1], was poor in five instances because of chest, visceral, or other involvement. In these patients there were sixteen other foci of active tuberculosis. In all hips there was fibrous ankylosis. Adduction, flexion, and rotation deformities of considerable degree were found. Three of the patients were completely bedridden because of the hip condition, and six could not bear weight even with crutches. In two of the patients the disease was very active, and in seven it was of minimal activity or quiescent.

Laboratory Findings: The Wassermann tests were negative throughout. Kidney involvement, not specific for tuberculosis, was present in three instances. Anaemia was present in every patient,—in one instance the hemoglobin being 30 per cent. Amyloid was also present in amounts varying from 20 to 100 per cent. The sedimentation rate was high in the patients with active hip-joint disease, and low in those in whom the

disease was quiescent. The concentrated specimens of two patients had low positive sputum ratings on the Gaffke scale.

Preoperative Care: Hip fusions previously attempted in seven of the patients had resulted in failure. All had been under extensive treatment of some kind, and one patient had had twenty-three operative procedures carried out on the hip (Fig. 1-A).

Complications: Shock of moderate degree was encountered once, and of slight degree, once. Deaths have occurred in three instances up to the present time. One postoperative death occurred at twenty-four hours, and, by autopsy, proved to be from an embolus. A second patient died three months postoperatively from uraemia with massive amyloidosis. The third patient, who died twenty-eight months postoperatively, had been fully ambulatory and bearing weight for two years preceding death (Fig. 1-B). She had extensive kidney involvement and died from uraemia and peritonitis.

Results: Of the nine patients operated upon, two died before ankylosis could be expected to occur. Of the seven others, five secured complete ankylosis, and one operated upon three months ago appears by roentgenograms to have satisfactory union. In one case the operation is definitely a failure. In this patient multiple sinuses preceded operation, and a single sinus still persists; ankylosis has not occurred. Where ankylosis has been secured, it has been with between 20 and 45 degrees of flexion, and with from little to moderate abduction. All clinical findings such as gait and sitting posture compare with results from ankylosis of the hip by routine procedures. The patients sit fairly well with 20 degrees of flexion, and very well when flexion is increased to from 30 to 40 degrees. Gait seems to be influenced by the amount of shortening present rather than by any other factor. Four of the five in whom ankylosis has been secured have been fully rehabilitated as far as weight-bearing is concerned. Full weight-bearing was secured in from four months to one year (Figs. 2-B, 3-B, and 4-C).

OPERATION

First Stage: When sinuses exist, it may be necessary to do a so-called first stage in an effort to get rid of the diseased trochanteric portion of the femur, remnants of the neck, fibrous tissue, and granulation tissue. The first operation then consists in an oblique division of the femur above the level of the tuberosity of the ischium, the pointed portion of the distal fragment jutting up and inward, the trochanteric mass, fibrous mass, and granulation tissue all being removed down to the fibrous tissue covering the old involved acetabulum and lateral surface of the ilium. In view of the usefulness of present drugs, such as sulfathiazole, it may be that some of these dissections can then be closed with the implantation of such chemical agents. The author has not done this to date, but has left the wounds open, packing them with vaseline gauze and treating them by the method of Orr, carbolizing them at interval dressings as necessary.

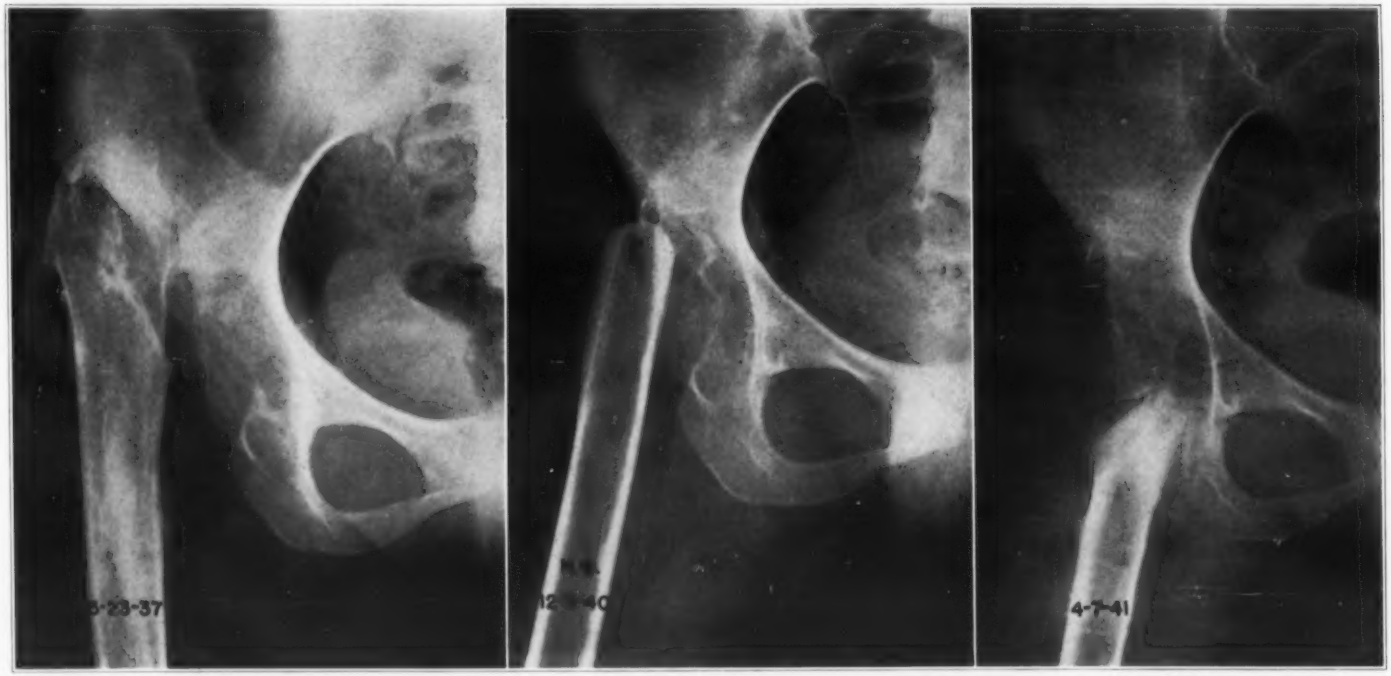

FIG. 4-A FIG. 4-B FIG. 4-C

H. G.: Proved tuberculosis of the hip of twenty years' duration in a patient twenty-three years old.

Fig. 4-A: March 23, 1937. Resection of the head and neck had been done previously elsewhere. Note fibrous tissue and underlying sequestra.

Fig. 4-B: December 3, 1940. Roentgenogram shows healed condition following first-stage amputation of the trochanter.

Fig. 4-C: April 7, 1941. Roentgenogram shows early union five months postoperatively; the joint is clinically solid.

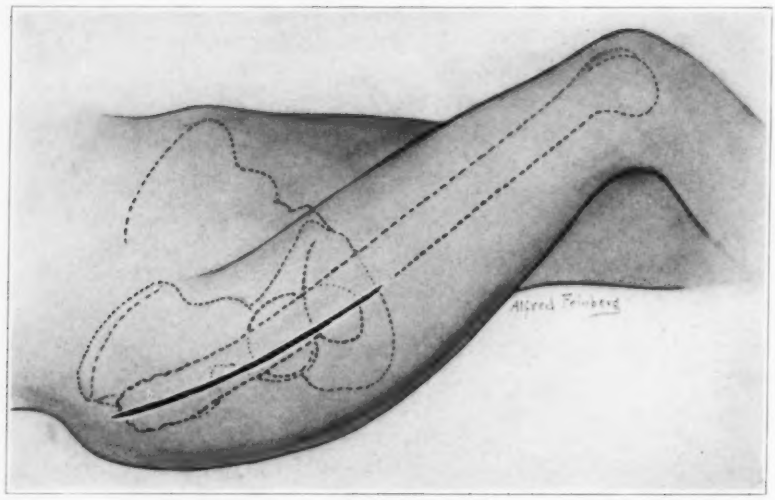

FIG. 5-A
Drawing shows lateral incision.

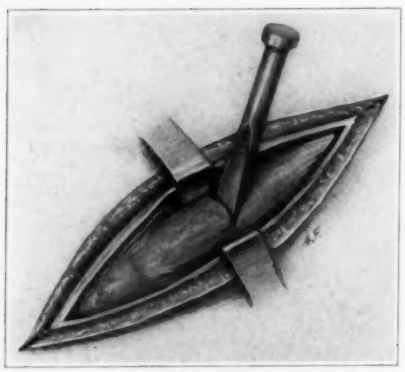

FIG. 5-B

Fig. 5-B: Subperiosteal dissection and osteotomy of femur upward and inward.
Fig. 5-C: The distal fragment is retracted.

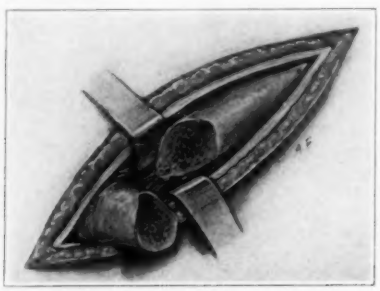

FIG. 5-C

Second Stage: The femoro-ischial transplantation itself can be done in one stage in all wounds without sinuses, and in the other patients when healing has been secured following the first stage. It should be known in advance that this is a difficult procedure for both the surgeon and the patient. Where sinuses exist away from the operative field, it is sometimes possible to do the femoro-ischial transplantation at a level below any roentgenographic evidence of the disease process. The procedure is carried out through a lateral incision, which extends from the trochanter well down on the femur through the fascia and vastus lateralis, with subperiosteal dissection of the femoral shaft opposite and just above the level of the tuberosity of the ischium. The shaft is then divided by osteotome upward and inward in an oblique fashion, so that

there is a point left on the distal fragment directed upward and inward. By blunt dissection the tuberosity of the ischium can be exposed on its distal and lateral surfaces, following retraction of the distal fragment of the femur. Though the dissection of the ischium can be seen by retraction and extension of exposure, the author has generally made the ischial exposure blindly and through a smaller opening than would otherwise be necessary. After denudation of a suitable place in the tuberosity of the ischium, a hole can be gouged out of the tuberos-

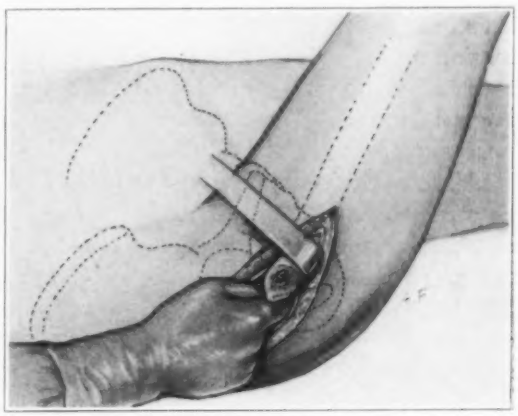

FIG. 5-D

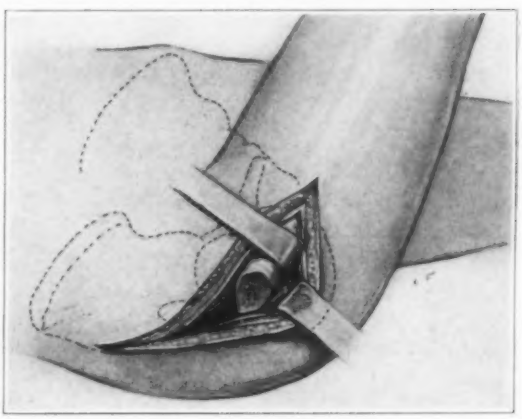

FIG. 5-E

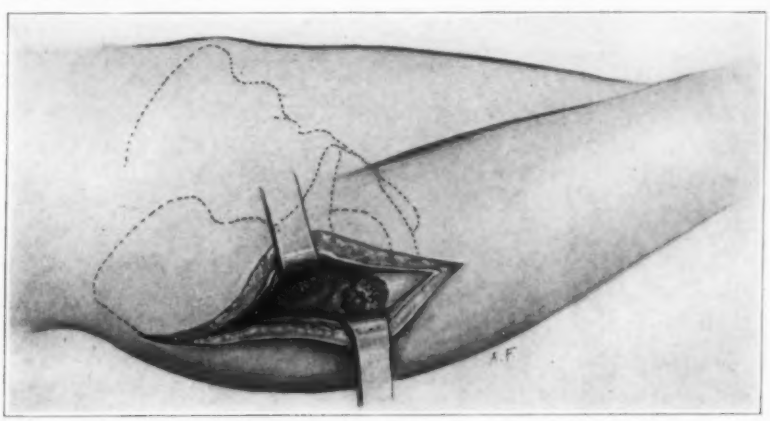

FIG. 5-F

Fig. 5-D

The ischium is located by palpation.

FIG. 5-E

A bone defect is created in the lateral surface of the ischial tuberosity.

Fig. 5-F

The sharp end of the femoral shaft is buried in the ischial defect. The proximal fragment of the femur, which has been removed for illustrative purposes, may be actually left *in situ*.

ity with a large curette. It should be noted that some judgment must be exercised as to the level of the femoral osteotomy. All of these legs show gross shortening and some length can usually be gained. The tightness of the fit of the femoral end in the tuberosity of the ischium, caused by the tension produced following implantation when the bone is cut long, tends toward stability and coaptation of the fragments. After the site has been prepared in the ischium, a large bone skid is placed with its point in the ischial defect, and the freshened end of the distal femoral fragment is levered into the defect in the ischium with the thigh flexed to about 90 degrees. By straightening the thigh to about 150 degrees, marked tension is then put on the musculature and fascia, jamming the end of the femur well into the prepared defect in the ischium (Figs. 5-A, 5-B, 5-C, 5-D, 5-E, and 5-F). It will be found that the periosteum and fibrous tissue, originally covering the denuded site in the ischium, surround the end of the femoral shaft in a semicuff. Little abduction should be used, shortening being compensated for later by prosthesis. The wound is well washed with ether to remove fat and debris, and is closed in layers with silk. A plaster double-hip spica is used for several weeks; the good leg is later removed from encasement, but the cast is not changed for at least three months. Roentgenographic evidence of union should be the guide for release from plaster retention and for the beginning of weight-bearing.

SUMMARY

The operative procedure described could be used in securing ankylosis in instances of old suppurative arthritis of the hip, aseptic necrosis, and ununited traumatic lesions, where ankylosis is desirable but difficult to secure, as well as for cases of tuberculous hip disease.

Femoro-ischial transplantation gives the same cosmetic, weight-bearing, and functional result (seated posture) as ankylosis of the hip joint.

1. Cleveland, Mather: Surgical Treatment of Joint Tuberculosis. J. Bone and Joint Surg., XXI, 607, July 1939.

CALCIFICATION AND OSSIFICATION

III. The Rôle of Local Transfer of Bone Salt in the Calcification of the Fracture Callus *

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The problem of the local transfer of bone salt in the healing of fractures can be stated in the following questions: (1) Is there a transfer of bone salt from bone to fracture callus, and, if so, how important a part does it play as a stimulus to healing, and as a source of the minerals required in the calcification of the callus? (2) If such a transfer to the callus occurs, is the bone salt derived from the portion of the shaft which becomes necrotic as the result of injury, from the uninjured and living cortical bone, or from both? (3) If such a transfer occurs, what is the mechanism of removal of the bone salt from preformed bone, of its local transport, and of its deposition in the calcifiable tissues of the fracture callus? (4) If local transfer of bone salt plays a significant part in the healing of fractures, can this process be supplemented by the local introduction of the minerals needed in the calcification of the fracture callus?

By applying the methods previously described [38, 39] for the study of the calcification process in experimental fractures, an attempt has been made to find answers to these questions. Because, as previously shown [39], the rachitic animal provides material better suited for the analysis of the process of calcification in the fracture callus than does the normal animal, the experiments reported have been carried out on rachitic rats. The uncalcified callus in rickets provides an ideal substratum for observations upon the local distribution and utilization of exogenous mineral and calcium salts transferred locally.

In the course of previous experiments [39], the local transfer of calcium salts from bone to callus was suggested by the observation that mineral deposits develop in the rachitic callus in the later stages of healing. This was termed *spontaneous calcification* to differentiate it from calcification induced by experimental means, and is recognizable as deposition of bone salt in the fracture callus in the absence of corresponding new calcification in the sites of new-bone formation elsewhere in the skeleton. Because the callus calcifies while the rachitic metaphyses remain unmodified, *spontaneous calcification in healing fractures* bears no necessary relationship to *spontaneous healing of rickets*, in which new calcification and early healing of the rachitic lesions all over the body occur in untreated individuals. Spontaneous calcification is much slower in rate than is calcifica-

* This work was aided by a grant from the Josiah Macy, Jr., Foundation.
† Henry Strong Denison Scholar for 1940–1941.

tion in rachitic animals subjected to treatment. In spontaneous calcification, even at the height of its progress, there are wide osteoid borders around incompletely calcified trabeculae, revealing the existence of a long interval of time between ossification and calcification. However, that calcium deposition is continuous, after spontaneous calcification is initiated, is shown by the fact that there is a continuous increase in the proportion of calcified to uncalcified callus as healing continues.

EXPERIMENTAL PROCEDURE

The results presented herein consist of observations upon histological sections of bones showing: (a) spontaneous calcification in rachitic fractures without interference, and (b) calcification in rachitic fractures as modified by (1) the administration of inorganic phosphate, (2) local implantation of ground bone, (3) introduction of devitalized onlay bone grafts, and (4) local injections of colloidal calcium phosphate. The rachitic rats, experimental fractures, serum calcium and phosphorus determinations, and microscopic preparations of the bones were obtained according to the methods described in previous papers [38, 39].

Spontaneous Calcification in the Fracture Callus in Rickets

Fractures were prepared in five litters of rachitic rats and allowed to heal, without interference, for periods of eight to twenty-eight days, when

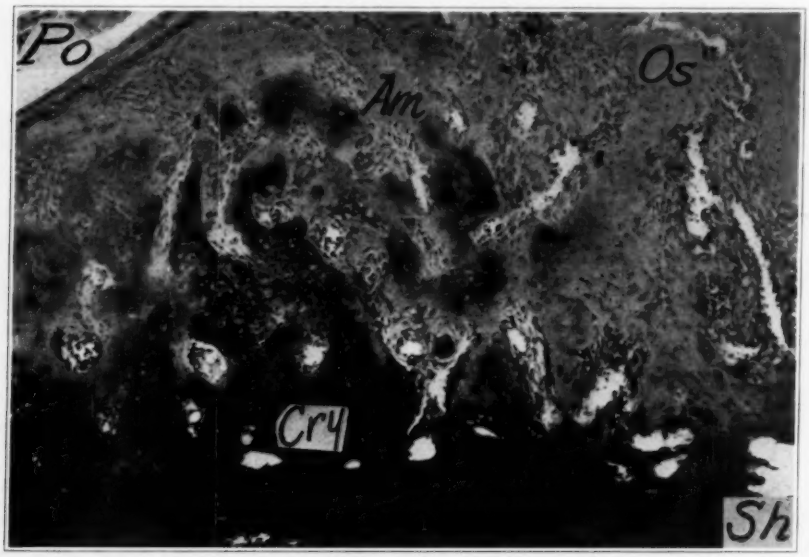

FIG. 1

Photomicrograph (× 88) of longitudinal section through fracture of undecalcified tibia of rachitic rat, aged fifty-nine days, after ten days of healing, showing the earliest stages of spontaneous calcification in the callus osteoid. *Sh*, indicates shaft; *Po*, periosteum; *Os*, callus osteoid; *Am*, amorphous deposits of silver; *Cry*, crystalline deposits of silver. (All sections illustrated were impregnated with silver nitrate and counterstained with hematoxylin-eosin.)

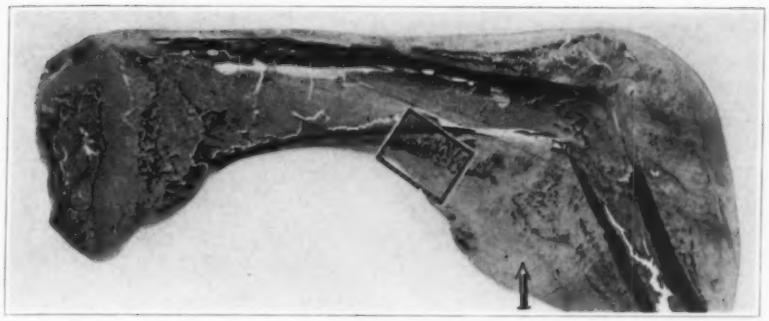

FIG. 2

Photomicrograph (× 6) of a longitudinal section through the undecalcified right tibia twenty-five days after fracture. Rachitic rat, seventy-four days old, weaned to Steenbock-Black rachitogenic diet 2965 at twenty-one days of age. There is complete absence of calcification in the epiphyseal cartilage and upper metaphysis, with new calcification widely distributed in the portion of the subperiosteal callus adjacent to the shaft, and in endosteal callus. Compare with figures in previous papers: Fig. 7[38], Figs. 20, 21, 22, 23, and 26[39]. Rectangle indicates area shown in Fig. 3, a serial section. Arrow indicates area shown in Fig. 4, a serial section.

the bones were excised for microscopic study. Under these conditions spontaneous calcification was observed in the callus as early as the tenth day of healing, but was found more frequently between the tenth and the fifteenth days. About one-third of the animals showed little or only be-

FIG. 3

Photomicrograph (× 53) of area shown by rectangle in Fig. 2, but from adjacent section, showing the density of the deposits of bone salt found in an advanced stage of spontaneous calcification. *Sh*, indicates shaft; *Po*, periosteum; *Os*, subperiosteal callus osteoid, with faint amorphous deposit of silver; *Sp*, spontaneous calcification in the callus osteoid; *Mw*, marrow.

FIG. 4

Photomicrograph (× 35) of an area around the rarefied fracture ends, indicated by the arrow in Fig. 2, but from an adjacent section, showing the final stages of the replacement of cartilage by osteoid. The cartilage, as well as the osteoid beneath the periosteum, is uncalcified, but solid union is initiated by the spontaneous calcification of the cartilage and bone matrix nearer the shaft. *Po*, periosteum; *Cr*, uncalcified cartilage; *C. Cr*, calcified cartilage; *Sp*, calcified osteoid.

ginning calcification as late as the fifteenth to the twentieth day, and, in occasional litters, notably those with very florid rickets or with bones showing wide metaphyses containing no old calcium deposits around the primary marrow cavity, the onset was sometimes as late as the twenty-fifth day of healing. Both the type and severity of the rickets, and the occurrence of spontaneous calcification were quite uniform among littermates reared under identical conditions.

Progress and Distribution of Calcium Deposition

Spontaneous calcification begins in the trabeculae of subperiosteal and subendosteal osteoid tissue overlying the fragments of the shaft for some distance from the fracture line. The bone salt is first seen in undecalcified sections impregnated with silver nitrate, as amorphous deposits or as fine crystals (Fig. 1). These deposits, which first appear in the callus osteoid applied to the surface of the cortical bone, spread outward toward the periosteum and later upward and downward toward the fracture line. The calcification gradually increases in density and in extent, but the dense calcification does not extend far enough to reach the periosteum. It usually terminates sharply, with the margin, parallel to the periosteum, facing a wide zone of osteoid (Figs. 2 and 3). This osteoid, lying between the periosteum and the osteoid which has calcified spontaneously, often contains small amounts of bone salt in amorphous deposits (Fig. 3), but up to the time that union occurs dense calcification is limited to the deeper portions of the callus.

Spontaneous calcification of the callus cartilage matrix, in all instances, begins after calcium deposits are widely distributed in the sub-

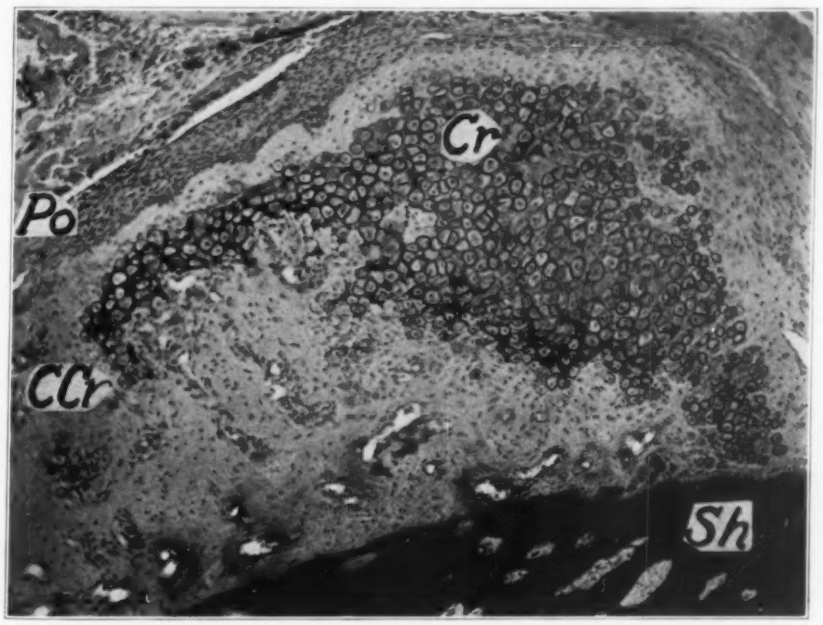

FIG. 5

Photomicrograph (× 60) of a section through the subperiosteal callus in a rachitic rat, aged sixty-seven days, eighteen days after a surgical fracture which had been implanted with particles of bone shown in Fig. 6. Beginning calcification in the hypertrophic cartilage facing the rarefied shaft, the surrounding callus osteoid remaining uncalcified, simulating the initial calcification of the epiphyseal cartilage in the earliest stages of healing of rickets (See Fig. 21 of a previous paper [39]). The implanted bone did not contribute to the local source of bone salt. *Sh*, shaft; *Po*, periosteum; *Cr*, cartilage; *C.Cr*, calcified cartilage.

periosteal osteoid. In a litter of fractured animals in which calcification began in the subperiosteal osteoid before fifteen days of healing, the matrix of the hypertrophic cartilage facing the shaft showed new calcium deposits at the eighteenth day. At this time, in addition to the hypertrophic cartilage, there is an abundance of fibrocartilage, chondro-osteoid, and fibrous connective tissue between the fracture ends and separating the cartilage from the subperiosteal bone. The initial calcification in the central callus is limited to the cartilage, and does not include the tissues in which it is embedded (Figs. 4 and 5). This selectivity is identical with that seen during the early stages of calcification induced by vitamin-D or phosphate administration, and confirms the previous observation [39] that the matrix of chondro-osteoid is not immediately calcifiable.

In spontaneous calcification of the cartilaginous callus, as in experimentally induced calcification, the deposits are laid down in its matrix only after the fibrocartilaginous tissue is invaded by blood vessels, mesenchyme, and osteogenic cells. The occurrence of calcification in the hypertrophic cartilage, in advance of the surrounding osteoid and chondro-osteoid, resembles the stage between the calcification of the epiphyseal cartilage and the healing of the rachitic metaphysis following phosphate or vitamin-D administration [39]. As the fibrocartilaginous callus is invaded, remnants of calcified cartilage, suggestive of the primary spongiosa of normal cartilage-bone junction, become enclosed in ingrowing osteogenic tissue and lamellae of new bone. When contact between the subperiosteal intramembranous bone and these central formations of new endochondral bone is established, the growth of bone then continues across the fracture line, and union is at irregular points.

Changes in the Shaft Accompanying Spontaneous Calcification of the Callus

At the time of the early stages of fracture healing in the experimental rachitic fractures which have been previously described [39], the compact bone of the shaft is relatively heavily impregnated with bone salt. There are only thin layers of new osteoid between the well calcified bone lamellae and the osteogenic cells which line the haversian canals, and the greater part of the cortical structure stains with silver to the maximum density. Shortly after the injury, necrotic cortical bone appears at the fracture ends, but this usually covers only a millimeter or less of the shaft, and is resorbed in the early stages of callus formation. As healing progresses, and as the callus organizes about the shaft for some distance from the fracture line—often one-third the total length of the shaft—the architecture of the enclosed compact bone is transformed and reconstructed. In the course of this process the bone salt is mobilized and is, presumably, in transit in the tissue fluids in solution, colloidal or ionic, but not aggregated in a form which can be visualized by silver-staining.

In a previous paper [38], the rarefaction of the shaft enclosed in callus was described in normal bones. In rachitic fractures, just as in normal fractures, it is observed that the vascular channels of the cortical bone be-

come widened and filled with osteoclasts, osteogenic tissue, and fibrous connective tissue, and that the shaft is reduced to such a state of porosis that the compacta becomes more nearly like spongiosa (Figs. 3, 4, and 5). As the callus reaches its maximum size, the cortical bone within it appears perforated by tortuous channels through which blood vessels, carrying an adnexa of mesenchyme and osteogenic tissue, pass from the marrow cavity and endosteal callus into the subperiosteal callus. At this stage, generally twenty-five to twenty-eight days of healing, when rarefaction of the shaft is at a maximum, the size of the callus and the distribution of spontaneous calcification are also at a maximum. With gradual resorption of callus there is reconstruction of the compacta. The new bone lamellae laid down concentrically in haversian systems are at first, as is the adjacent callus osteoid, only partially calcified, but gradually increase in density as the size of the callus becomes reduced. As the callus becomes so organized that union is approached, calcification is extended to the tissues between the fracture ends.

Union

Spontaneous calcification of the osteoid and hypertrophic cartilage matrix between and around the fracture line may be regarded as the initial stage of union, although for some time the density of these deposits is so slight that, in ordinary roentgenograms (See illustrations of the papers of Compere, Hamilton, and Dewar; and Ham, Tisdall, and Drake), there is little or no suggestion of the presence of calcification in the rachitic callus. Owing to the presence of uncalcified chondro-osteoid, fibrocartilage, and dense fibrous connective tissue across the fracture line, the continuity of the newly calcified tissue is irregular and interrupted at

TABLE I

RELATION OF SPONTANEOUS CALCIFICATION IN THE CALLUS TO THE CONCENTRATION OF CALCIUM AND PHOSPHATE IN THE PLASMA

Groups	No. of Animals	Days of Healing	Calcium (*Millimoles Per Liter*)	Phosphorus (*Millimoles Per Liter*)	No. of Animals Showing Spontaneous Calcification
Fractures	5	10	2.74	1.58	0
Controls	4	–	2.76	1.56	–
Fractures	4	12	2.79	1.84	1
Controls	4	–	2.78	1.80	–
Fractures	4	18	2.77	1.58	3
Controls	3	–	2.80	1.55	–
Fractures	3	22	–	1.45	3
Controls	3	–	–	1.44	–

various points. In some cases, there is actual retraction of the fibrocartilaginous callus between the fracture ends, suggesting the development of changes leading to non-union.

Serum Calcium and Phosphorus During Spontaneous Calcification of the Callus

Four litters of rachitic rats were divided into two groups, one of which served as a control. Fractures were prepared in rats in the other group, and the bones were allowed to heal for periods of ten, twelve, eighteen, and twenty-two days. At these times, the animals were sacrificed and the blood in each group pooled for serum calcium and inorganic phosphorus determinations. The bones were sectioned manually and subjected to the silver-nitrate "line test" to ascertain the presence or absence of calcification in the callus. The results are summarized in Table I.

There were no significant differences in the levels of the serum calcium and phosphorus in the pooled sera of fractured, as compared with unfractured, littermates; although in sections of the bones there were mineral deposits in the callus in many instances. Therefore, it seems clear that at the time of spontaneous calcification of the callus the state of the blood of fractured and unfractured littermates is the same with respect to calcium and phosphorus.

Spontaneous Calcification as Modified by Generalized Calcification

Three to four littermates of each of the five litters of rachitic rats, in which spontaneous calcification has been described, were given daily intraperitoneal injections of phosphate solution in uniform doses. The phosphate solution used was a mixture of 80 per cent. of one-tenth molar secondary sodium phosphate (M/10 Na_2HPO_4) and 20 per cent. of primary sodium phosphate (M/10 NaH_2PO_4), of which the hydrogen-ion concentration at 38 degrees centigrade corresponded approximately to pH 7.35. The standard dosage employed was 2.5 cubic centimeters (containing approximately 7.5 milligrams of phosphorus) per 100 grams of rat weight. The daily injections were begun in four litters at eight days following the fracture, and in one litter at fifteen days.

These experiments are presented in order to demonstrate the contrast between calcification arising from humoral sources and that from local sources. The control, progress, and maintenance of calcium deposition in the rachitic callus by means of inorganic phosphate administration were described in detail in a previous paper [39], but at this point it is to be shown that calcification of the callus in conjunction with generalized healing of rickets follows a pattern which is peculiarly different from that of spontaneous calcification.

In rachitic rats with healing fractures, injected intraperitoneally with phosphate on the eighth day of healing, calcium deposits may be found on the tenth day in the callus osteoid which lies immediately under

the periosteum, and there are also the expected calcification and early healing changes in the rachitic epiphyseal cartilage and metaphysis. With continued daily injections from the tenth to the twelfth day of healing, the initial subperiosteal deposits increase in density, and new deposits form farther inward toward the shaft. Continuing from the twelfth to the fifteenth day, partial calcification of the osteoid appears everywhere in the subperiosteal callus and in the various parts of the fibrocartilaginous callus in contact with osteogenic tissues. With continued injections from the fifteenth to the twenty-fourth day, there is usually rapid invasion and replacement of the fibrocartilaginous callus by bone, and, in a few cases, there may be enough calcified bone across the fragments to regard the fracture as microscopically united.

In this way the callus calcifies by progressive impregnation which spreads centripetally from the periosteum to the shaft; and, if in the interim spontaneous calcification has occurred, its presence and contributions to the deposits are obscured by the rapidity and completeness of the calcification derived from humoral sources (See illustrations of the paper of Urist and McLean [39]).

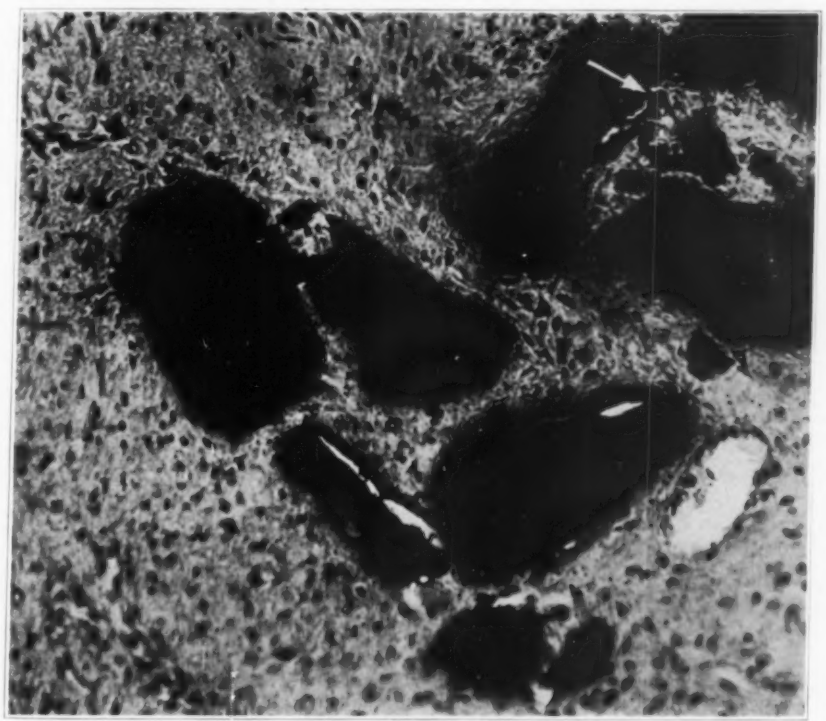

FIG. 6

Photomicrograph (× 250) of section showing necrotic bone eighteen days after implantation between the cortical ends of a surgical fracture in a rachitic rat. The particles of dead bone are encapsulated in fibrous connective tissue and absorbed with granular crumbling and disintegration of the bone matrix. The arrow indicates a macrophage shown in Fig. 7.

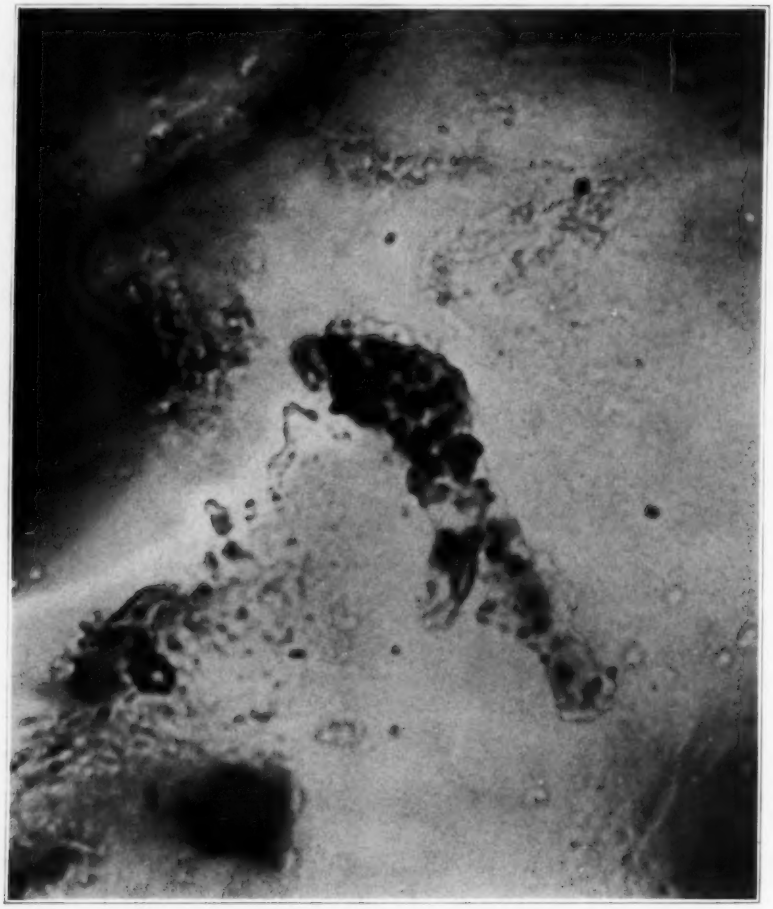

FIG. 7

Photomicrograph with an apochromatic immersion objective (× 3000) showing a macrophage indicated by the arrow in Fig. 6, with cytoplasmic granules of silver-staining material, presumably bone salt.

In animals first injected with phosphate on the fifteenth day, granular deposits of bone salts, judged to originate in spontaneous calcification, are found, at the eighteenth day, immediately adjacent to the shaft, along with the denser deposits that form in the subperiosteal osteoid. The callus osteoid between these lines of calcification is either entirely free of bone salt or only very slightly impregnated with isolated patches of discrete crystals. This presumably represents an area being encroached upon from both the centrifugal direction of spontaneous calcification and the centripetal direction of calcification supported by humoral sources of the bone salt. Thus the local mechanism of delivering the materials necessary for building the bone salt does not differ from the more rapidly progressive humoral mechanism in its selection of the tissues undergoing calcification. Calcification occurs only in the osteoid and in

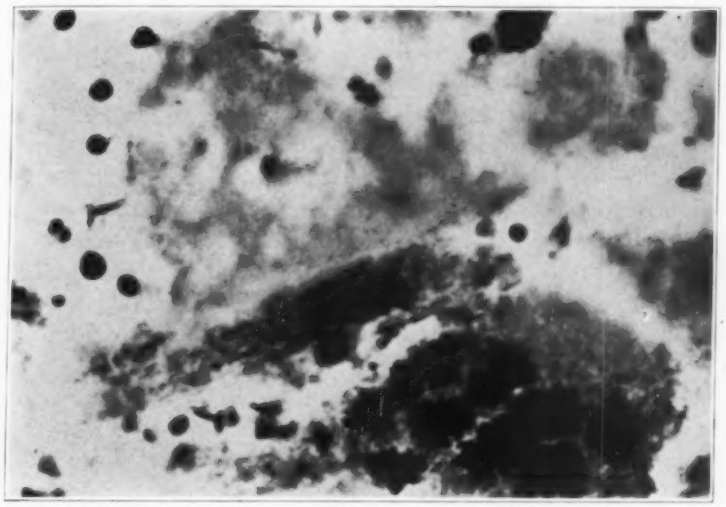

FIG. 8

Photomicrograph (× 670) showing two fragments of dead bone undergoing decalcification and autolysis twenty days after implantation in the marrow cavity between the cortical ends of rachitic surgical fractures. The lower fragment has become so depleted of its mineral substance that the chemical reaction with silver nitrate results in the formation of large crystals of calcium salt. The effect is also seen in rapidly forming bone and in newly calcified osteoid, except that the crystals are smaller, and the direction of the process is the reverse,—calcification rather than decalcification (See Fig. 25 of a previous paper [39]). The fragment in the upper part of the picture is seen in the final stages of autolysis. Inflammatory tissue and serous exudate comprise the surrounding background.

the hypertrophic cartilage in contact with invading mesenchyme or osteogenic tissue; likewise the resistant properties of the chondro-osteoid and non-osseous tissues are the same in spontaneous calcification as in generalized calcification resulting from vigorous antirachitic treatment.

The Callus of Rachitic Fractures Implanted with Devitalized Bone

Subperiosteal fractures were prepared surgically in two litters of rachitic rats. In one litter, approximately equal quantities by volume of ground bone were inserted between the fracture ends at operation. In the second litter, thin bone platelets of equal size were placed under the periosteum and applied to the shaft across the fracture line in the manner of an onlay bone graft. The particles of bone, cut from autoplastic scapulae and ilia, had been devitalized in strong alkali and washed in distilled water. Similar surgical fractures were implanted with pieces of 60-degree paraffin of equal size in order to provide controls to show the effect of obstruction at the fracture line.

Ground Bone

The healing of rachitic fractures implanted with particles of dead bone follows the same course as that of undisturbed fractures, except that

the structure of the central fibrocartilaginous callus becomes modified by the cellular reaction to the presence of foreign bodies. The formation of uncalcified osteoid tissue, which begins some distance from the fracture line in the subperiosteum and subendosteum, proceeds rapidly in the first fifteen days of healing, as is characteristic of rickets, and there is little or no invasion of the central callus by bone. Instead of the central fibrocartilaginous callus being uniformly comprised of nodules of cartilage within and about proliferating fibrocartilage and fibrous connective tissue, there are distributed within it particles of the implanted dead bone surrounded by foreign-body giant cells and fibrous connective tissue. The closely outlying osteoid and cartilage of the rachitic callus show no calcium deposits or changes attributable to the presence of dead bone in the callus. The devitalized bone particles gradually decrease in size by the process of granular crumbling within the fibrous connective-tissue envelope, and stain deeply eosinophilic and to the maximum density with silver (Fig. 6). As this process progresses, the matrix stains poorly and irregularly with eosin, and the calcium content diminishes. An occasional particle appears which shows the silver salt aggregated in the background of uncalcified matrix (Fig. 8), and an occasional particle may be found which shows no bone salt in the disintegrating acellular tissue (Fig. 8).

In the fibrous connective tissue, and between the foreign-body giant cells surrounding the crumbling necrotic bone, are phagocytic cells, containing cytoplasmic granules of silver-staining material (Fig. 7). These cells resemble the macrophages which have been seen surrounding the necrotic cortical ends in normal healing fractures and but rarely in rachitic fractures [38].

Between fifteen and twenty days of healing, when calcification occurs in the subperiosteal regions and later in the cartilage of the implanted callus, the new deposits do not appear to be more dense than in the untreated controls or to differ in any way from those seen in the usual progress of unmodified spontaneous calcification.

Onlay Grafts

In one litter of rachitic rats, devitalized onlay bone grafts were introduced across the fracture in order to observe the fate of the implanted bone in the relatively unobstructed growing callus. The results appear the same as in the case of the callus implanted with bone particles. The grafts are absorbed rapidly and do not alter the usual progress of spontaneous calcification or the rate of development of the rachitic callus.

The Callus of Rachitic Fractures Injected with Colloidal Calcium Phosphate

In one litter of rachitic rats, the subperiosteal callus, beginning at seven days, was injected every two days with one-twentieth molar (M/20) of colloidal solution of calcium phosphate by means of a fine-caliber hypodermic needle. This solution was prepared by mixing solutions of one-tenth molar of calcium chloride (M/10 $CaCl_2$) and one-tenth molar of

balanced secondary sodium phosphate and primary sodium phosphate (M/10 balanced Na_2HPO_4 and NaH_2PO_4) in an equal quantity of pig serum which was used as the protective colloid. The bones were resected at intervals of three, five, and ten days from the eighth to the twenty-fifth day of healing.

Local injections of calcium phosphate in colloidal solution fail to initiate calcification of the osteoid tissue of the rachitic callus. The material is evidently received as if it were a chemical irritant. The callus tissues appear disorganized by local dilatation of the sinusoids and capillaries, by infiltration of large masses of polymorphonuclear leukocytes, macrophages, and inflammatory exudate, and by the formation of foreign-body giant cells and granulation tissue. In frozen-dried, hand-cut sections, stained with concentrated silver-nitrate solution, there were groups of macrophages containing granular material in the cytoplasm which stained after the manner of the phosphate salts. But histological sections did not reveal more than a suggestion of the presence of these cells. The advent of spontaneous calcification in the inner portion of the subperiosteal callus osteoid and cartilage was observed at the usual time in such areas as were not infiltrated with inflammatory tissue. The deposits are not more dense than those seen in untreated littermate controls.

DISCUSSION

Spontaneous calcification in the callus in untreated rachitic rats is characterized by (a) its *late appearance*, long after readily calcifiable tissues have appeared in the callus; (b) a characteristic *pattern* of distribution, first in the callus osteoid, adjacent to the callus-enclosed shaft, spreading outward toward, but not reaching, the periosteum; (c) a marked *limitation in the capacity* of the mechanism, resulting in deficient or defective union; (d) a definite *diminution in rate* of calcification; (e) appearance of calcification in the callus *without corresponding calcification or healing in the rachitic metaphysis;* (f) its occurrence *without the increase in calcium or phosphate concentrations in the plasma* characteristic of humorally induced calcification. These characteristics are sufficient to establish the fact that local transfer of calcium salts from bone to fracture callus may occur. They serve also to emphasize some of the limitations of this source of mineral in the calcification of the callus.

Local Calcium Salt as a Stimulus to Osteogenesis

There are repeated suggestions in the literature that calcium salts play an important part in stimulating osteogenesis. The earlier literature is reviewed by Wells. Axhausen suggested that the resorption of necrotic bone may be the stimulus to new-bone formation in healing fractures. The view of Leriche and Policard, that a "local excess of calcium" stimulates the differentiation of connective tissue into bone, has been much quoted, it being frequently inferred that the calcium salts are deposited concurrently in the new bone. Eden considered calcification of em-

bryonic connective tissue as the forerunner of ossification. All of these suggestions imply that deposition of the bone salt, following injury to bone, precedes rather than follows formation of bone.

It has previously been shown [38], in fractures in normal rats, that there is no indication of deposition of bone salt in the procallus, and that such deposition occurs only after the formation of a calcifiable tissue,—namely, the matrix of bone or of cartilage. The observations here reported, of the late appearance of spontaneous calcification in the rachitic callus, long after calcifiable tissues are present, constitute adequate evidence that the formation of osseous tissue in the fracture callus is not dependent upon the presence of bone salt.

The Shaft as a Source of Bone Salt

The foregoing observations indicate that the source of the mineral transferred from bone to fracture callus is that part of the shaft enclosed in the callus. As described by Cornil and Coudray, this portion of the shaft consists of two distinct parts,—the *necrotic* bone at and near the site of the fracture, and the *living cortical tissue*. The alteration of the structure of the shaft near the healing fracture has been described in gross specimens by Todd and Iler, in injected bones to show the course of the blood vessels by Lexer, and in undecalcified microscopic sections by Urist and McLean [38, 39]. In general, the cortex is resorbed and rarefied preliminary to replacement of the old shaft by new bone. The adjacent subperiosteal and intramedullary callus reinforces the shaft while the fracture gap is being bridged by new bone.

Murray [24, 25, 26] who considers local transfer of bone salt to be the most important source of mineral for the repair of fractures, contends that the source of the calcium is the dead bone at the site of the fracture. His views, derived chiefly from the implantation of calcium salts or devitalized bone into experimental fractures, will be considered further.

Urist and McLean have previously described [38, 39] the fate of necrotic bone in fractures in normal rats, and have shown that it disintegrates and becomes decalcified, and is removed by a process which differs from the resorption of living bone. This process is at its height from the fifth to the tenth day of healing, and by the fifteenth day decalcification and disintegration of the necrotic fragments may be complete. On the other hand, resorption and reorganization of the living, callus-enclosed shaft, which begins with the first formation of the subperiosteal intramembranous bone, and continues throughout the growth and regression of the callus, reaches its height at the twenty-fifth to the thirtieth day of healing, by which time the shaft has become almost as porous as spongy bone. The course of reconstruction of the shaft in rachitic bone, as described in the present paper, is identical with that in normal animals, and is closely correlated in time with the spontaneous calcification observed in the rachitic fracture callus.

Moreover, the observations here reported demonstrate a close ana-

tomical relationship between the portion of the shaft undergoing rarefaction and the osteoid tissue in process of calcification, and fail to disclose such a relationship between necrotic bone and the distribution of its mobilized salts. Calcium salts, other than those contained in living bone, whether in tissue necrotic as a result of injury or artificially introduced, as will be shown later, are treated by the organism as foreign bodies, without their diffusion into adjacent tissues. Consequently it does not appear that necrotic cortical bone of the fracture ends can be an important source of mineral to be used for calcification in the fracture callus.

The Blood Calcium and Phosphorus During the Period of Spontaneous Calcification of the Callus

Between the tenth and twenty-second day of healing, when spontaneous calcification of the callus may be expected in rachitic fractures, the levels of the serum calcium and phosphorus do not vary more than within the limits of error of the chemical methods of determination. However, detailed studies upon the effect of a fracture of bone on the serum calcium and phosphorus in laboratory animals and human beings, and on the metabolism of nitrogen, potassium, sodium, sulphur, sulphate, phosphorus, phosphate, creatine, and creatinine in the rat [10] have shown various changes in the concentration of these elements in the blood and urine, but the author is unable to correlate them with the course of spontaneous calcification. These changes which seem to be part of the reaction of the body as a whole to injury [10] become pronounced within the first six days of healing, whereas spontaneous calcification is an event of the later stages of the healing.

The majority of investigators [5, 11, 16, 23, 27, 30, 31, 36] have found a rise in the level of the serum phosphorous of one to two milligrams per 100 cubic centimeters in clinical and experimental fractures, usually during the first week of healing, and little or no change [5, 23, 27, 30] in the level of the serum calcium, but there are also recent reports that the serum calcium is elevated during the progress of bone formation in the callus [3, 28, 35]. The latter have not, however, presented data sufficient to show that the magnitude of the change in the serum calcium is greater than the normal range of nine and five-tenths to eleven and five-tenths milligrams per 100 cubic centimeters of blood, or that the observations differ from those reported by others [5, 23, 31] and regarded as irregular variations to which no significance can be attached [27, 30].

Local Introduction of Bone Minerals into the Fracture Area

There is an extensive literature on attempts to influence the healing of fractures by the local introduction of bone minerals. Although not always recognized, at least three questions are implied by these experiments: Is bone mineral, locally introduced, (1) a stimulus to the initiation

of osteogenesis; (2) is it a stimulus to the rate of osteogenesis; and (3) is such bone mineral used in the calcification of the callus?

The author has already considered the question of the influence of calcium salts on the initiation of osteogenesis, concluding that the formation of osseous tissues in the callus is not dependent upon the presence of such salts. Experiments on local introduction of calcium salts into the fracture area have contributed little to this aspect of the problem, as these experiments have been chiefly concerned with end results. The problem of ununited fractures is not under consideration here.

On the one hand [1, 4, 17, 24, 25, 32, 34] it is contended that local introduction of various calcium salts, in solution or in suspension, or in the form of devitalized bone, influences the healing of fractures favorably, as determined in various ways. Similar experiments, by other investigators [6, 19, 20, 33] have led to opposite conclusions. From none of these experiments is it possible to give categorical answers to the question of the osteogenic effect of implanted bone mineral, and, as Shands states, the positive results do "not prove that the calcium is actually used in the calcification of the bone matrix".

The experiments upon local introduction of bone salt presented in this paper, performed in the presence of osteogenesis following fractures, and proceeding at what may be assumed to be a maximum rate, can give no answer to questions concerning the influence of calcium salt on osteogenesis. They do, however, give some information concerning the availability of salts so introduced in the calcification of osseous tissue, this information being chiefly of a negative character.

The author has found that local injections of colloidal calcium phosphate or implantations of devitalized bone do not initiate calcification in the osteoid of the rachitic callus, a tissue which is readily calcified either by local transfer of bone salt, or by minerals transported by the blood. As also found by Eden, and as described by Huggins, McCarroll, and Blocksom, the author has observed that implanted or injected mineral substances produce inflammatory changes and foreign-body reactions in the tissues, and that encapsulation and absorption follow throughout the first twenty days of healing. As is not the case in the resorption of living bone, where in association with osteoclast formation the bone salt and the bone matrix are resorbed at the same instant, the implanted dead bone is often decalcified in advance of its disintegration or autolysis. The dead bone or calcium salts appear to be dissolved in the tissue fluids without influence upon the osteoid or cartilage lying outside the fibrous connective tissue in which it was encased. These results lead to the conclusion that the introduction of inert mineral substances or dead bone does not influence calcification locally. It may be assumed either that local transfer is prevented by chemical conditions within the foreign-body reaction which develops around these substances, or that mobilization of the bone salt in chemical state suitable for local redeposition is a function of the living bone cells.

The Significance of Local Transfer of Bone Salt in the Healing of Fractures

The experimental findings presented have excluded the local transfer of bone salt as the stimulus to the initiation of osteogenesis following experimental fractures, and has found no evidence that it influences the rate of bone formation in the callus, except in so far as has previously been shown [39] that the orderly processes of replacement of the fibrocartilaginous callus by osseous tissues are in part dependent upon the concurrent calcification of this tissue. It has been shown, however, that local transfer of mineral from living bone to callus does occur, and some attempt to evaluate the importance of this process in the healing of fractures seems desirable.

It has been repeatedly reported that union of fractures, in both clinical [8, 14, 21, 24] and experimental [13, 29] rickets occurs spontaneously, although with considerable delay, and often with some deficiency in the mechanical strength of the fracture site. The development of calcification in the callus in rickets, a condition in which calcium deposition fails to take place in all other sites of new-bone formation, can be explained chiefly, if not entirely, on the basis of the local transfer of mineral. Thus local transfer of bone salt is responsible for the calcifying of the callus under conditions adverse to calcification of the skeleton in general. Under moderate conditions of mineral deficiency, under depressed conditions of mineral metabolism as in old age, or under extraordinary demand for new bone and bone salt as in cases of multiple fractures, the increment of calcium salt supplied to the callus by local transfer may be necessary for the achievement of the normal rate of calcification.

Of more general interest is the rôle of this local mechanism in the healing of fractures under normal conditions of mineral and vitamin intake, particularly in view of the widely accepted statement of Murray [26] that "the effective source of calcification for callus in the primary healing process following fracture is the traumatized bone at the site of the fracture". The author's view, as supported by evidence reported here and previously [38, 39], differs sharply from Murray's and that adopted by others [7, 15]. Briefly stated, the author's view is that while local transfer of bone salt occurs, it is chiefly from the living shaft, rather than from necrotic bone; that it occurs only after the portions of the shaft adjacent to the fracture have become enclosed in callus; and that the capacity of this mechanism is too limited to be the "effective source of calcification" of the callus. The same mechanism by which growing bone is calcified, and by which the ordinary wear and tear of bone is compensated for—that is, the humoral transport of bone mineral—is of far greater importance in the healing of fractures in normal individuals under normal conditions of mineral intake.

It is true that this conclusion is based largely upon experiments upon rachitic animals, and that the objection may be raised that the capacity of the mechanism of local transfer of bone salt in such animals does not necessarily reflect the capacity of the similar mechanisms in animals with

normally calcified bones. While this objection has some slight validity, the density of calcification of the fractured shafts of the bones of the rachitic animals is not sufficiently less than that of the shafts from normal animals to permit the belief that the general conclusions are materially altered by the nature of the experimental material.

It is well known that the inorganic-phosphate concentration of the plasma in the adult is considerably below that of the infant, and is so low that it is difficult to account for the calcification of bone in the adult on the basis of the solubility of the phosphates of calcium. Moreover, reports on the calcium and phosphate levels in the plasma of adult individuals with healing fractures are conflicting, but do not lead to the conclusion that increased concentrations of these substances in the plasma are essential to normal calcification in the callus. It is conceivable, although not demonstrated, that the resorption of the callus-enclosed shaft, with diffusion of the dissolved or colloidal calcium salt into the fracture callus, may assist in raising the local concentrations of the ions of the bone mineral to such an extent as to aid in precipitating the mineral ions transported in the blood. This interpretation is suggested by the observations that calcification advances centrifugally to a sharp line which is parallel to the periosteal blood supply (Figs. 2 and 3). Thus transfer of bone salt, increasing the local concentration of calcium and phosphate ion, may *determine* and delimit the site of calcification; the source of the bone mineral, however, must be chiefly humoral.

SUMMARY

1. Spontaneous calcification of the rachitic callus in the later stages of healing has been described in detail, and has been shown to be responsible for the consolidation of fracture in rickets.

2. Spontaneous calcification of the callus has been defined, on the basis of observations upon the blood calcium and phosphorus, and upon undecalcified histological specimens which demonstrate the bone salt, as calcification which is progressive and limited to the fracture area. It is not accompanied by any change in the levels of the blood calcium and phosphorus, or in the existing state of the rachitic metaphyses. The calcium salts are laid down in the osteoid and cartilage of the tissues adjacent to the shaft in a characteristic pattern which is clearly distinguishable from calcification which follows administration of phosphate solution or vitamin D, and results in healing of the rickets.

3. The necrotic and uninjured portions of the section of the shaft which is enclosed in the growing callus have each been considered as possible sources of the calcium salts deposited in spontaneous calcification of the callus. The fact that the living cortical bone, by far the greatest portion of the length of the shaft enveloped in callus, becomes considerably rarefied when the callus reaches maximum size, and at the time when spontaneous calcification reaches its maximum distribution, suggests that this calcification represents local transfer of calcium salts from the

shaft to the callus. Since the necrotic portion of the section of the shaft surrounded by callus is only a small fraction of the bone mineral stored in the cortex at the fracture area, it is believed that if it contributes to local transfer in the course of its absorption, the amount of bone salt thus liberated is relatively insignificant and cannot be regarded as an important source of the calcium salts deposited in the callus of healing fractures.

4. Because local implantations of devitalized bone or injections of colloidal calcium phosphate into the rachitic callus osteoid, prior to the advent of spontaneous calcification, fail to initiate calcification, it is concluded that these substances cannot be regarded as local sources of the bone salt. The differences in the mechanism of the resorption of living bone, as compared with the process of the absorption of dead bone or calcium salts, suggest that the local redistribution of the bone salts in the area of a healing fracture is brought about by the activity of the cellular elements of the bone, possibly the osteoclasts.

5. The phenomenon of local transfer of calcium salt may be regarded as indirect experimental evidence of local increase in concentration of dissolved calcium salt in the extracellular fluid of living bone undergoing resorption.

CONCLUSIONS

The rôle of local transfer of calcium salt from shaft to new bone in the healing of fractures is considered that of a reserve mechanism which aids in consolidating callus under conditions adverse to calcification of the skeleton in general. The humoral source of bone salt is essential for the normal progress of healing, and cannot be entirely replaced by local sources of mineral without considerable delay in the uniting of fractures. Resorption of cortical bone, the process leading to local transfer of bone salt, does not appear until the later stages of healing, does not progress at a rate parallel to osteogenesis, and fails to supply the quantity of mineral needed to calcify the existing callus at any one time. Bone salt originating locally in necrotic bone or implanted in the callus is absorbed without influence upon the progress of calcification of the new bone and cartilage matrix.

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THE CLINICAL SIGNIFICANCE OF CERTAIN MICROSCOPIC CHANGES IN MUSCLES OF ANTERIOR POLIOMYELITIS *

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The pathological changes which occur in the muscles of anterior poliomyelitis have received very little study. The gross changes have been entirely neglected until recently[14], and the work [2, 12, 13, 17, 26] that formerly had been done on the microscopic changes was largely of a descriptive nature.

It is only natural that muscle function and muscle pathology should be closely interrelated. This was found true in the investigation of the gross pathological changes, and likewise should be largely true in the microscopic study. Since this study was made on living muscles in living patients and the actual strength and condition of the muscles was known, it was possible to correlate certain microscopic findings with certain types of muscle behavior.

Obviously it is fallacious to try to analyze the complete behavior of any one muscle from the microscopic appearance of one or two tiny sections from that muscle; yet certain generalizations on muscle function and microscopic appearance can be pointed out and acceptably entertained.

It is the purpose of this paper to describe certain of these interesting microscopic findings, and to analyze these findings in the light of muscle behavior.

METHOD OF STUDY

This study was made on patients who had had the disease two years or more. The muscles were carefully studied, graded, and often given physiotherapy for varying periods of time before the operation. Some standard operation that the patient needed was done. The incision, however, was lengthened enough so that in nearly every case the full muscle was visualized. Sections for microscopic study were removed from the most damaged part of each muscle.

Grossly the muscle shown in Figure 1 (P. R.) was rather homogeneously involved. The history indicated an early complete paralysis. Some return in contractile power occurred in the next few weeks. During the subsequent year a slight progressive increase in strength occurred. For several months it had remained at this stage, much improved over its original postparalytic strength, but not normal. It had apparently reached a definite standstill in its ability to gain more strength.

This section shows three interesting things often found in poliomye-

* This study was aided by a grant from The National Foundation for Infantile Paralysis, Inc.

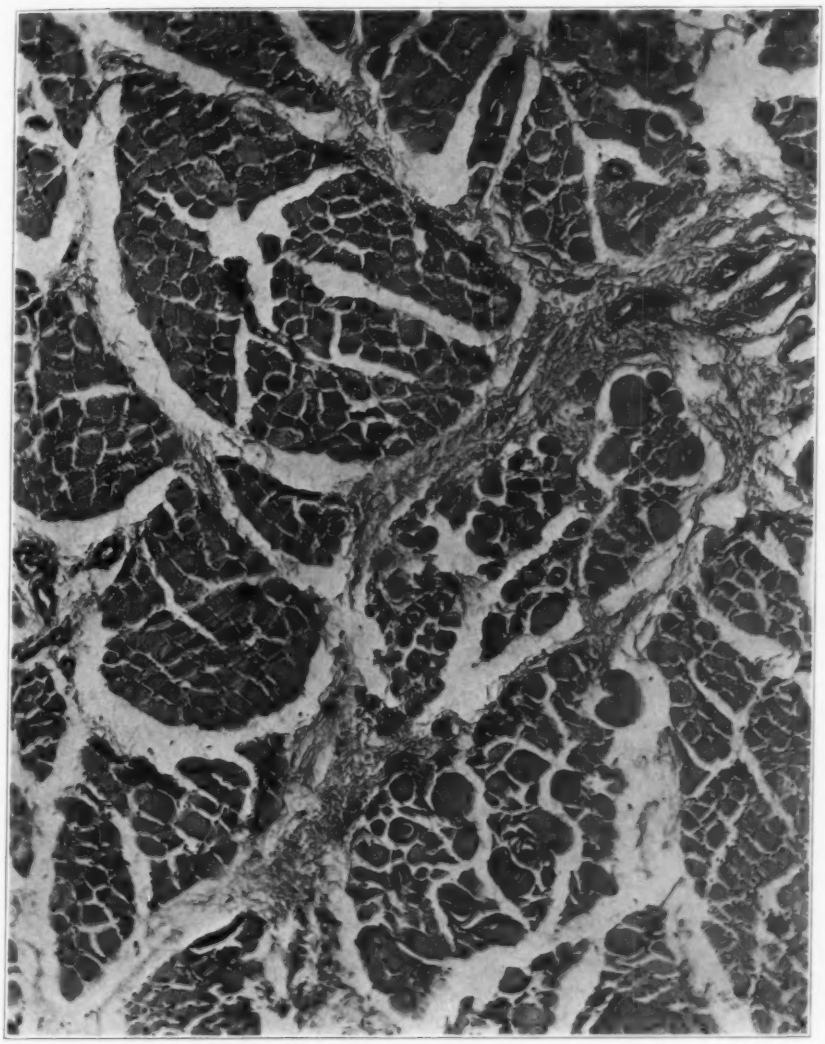

FIG. 1

P. R. Muscle grade was poor plus. Photomicrograph (× 1000) shows the decreased number of cells in the bundles near the center; the increased interfascicular fibrosis about the involved bundles; and the large round hypertrophied cells in bundles containing a lessened number of cells.

litic muscle. There is increased interfascicular fibrosis; this is present only around those bundles which have been damaged, and does not fill in the interspaces between normal-appearing bundles. There is atrophy and disintegration occurring in many cells; only a cellular debris remains in some places. The most interesting finding, however, is the large round cells. They are present only in those bundles which also contain the atrophic and disappearing cells; they do not occur in normal bundles. They appear to be perfectly normal, and they stain with van Gieson stain

FIG. 2

N. O. N. Muscle grade was fair minus. Photomicrograph. (× 1000) shows fairly good-looking cells and very marked atrophic cells lying side by side in the same muscle. Note the apparent increase in the number of nuclei in the atrophic zone.

exactly as do normal muscle fibers. If they were not viable, they also would be undergoing the atrophic and disintegrative changes seen in other cells. Since they are viable, and since they occur only in bundles containing atrophic cells, it is most likely that these are cells which have become hypertrophied. They are apparently trying to compensate for the weakness in that bundle due to the loss of the other cells. It probably represents a compensatory hypertrophy.

The early recovery in strength made by this muscle was likely due

FIG. 3

E. S. Muscle grade was poor plus. Photomicrograph (× 1000) shows good cells below and a zone of fibrous replacement of muscle cells immediately above.

to the subsidence of swelling and oedema in the spinal cord, which may have compressed or rendered impotent certain motor neurons not actually destroyed. The slow gradual improvement that occurred the next year was probably due to the compensatory hypertrophy of viable cells.

Studies on muscle physiology by Clark, and Eccles and Sherrington, and others indicate that from each anterior-horn cell in the spinal cord there emerges an axon which goes through the anterior nerve root and down through the nerve to the muscle. Here, just before and after

entering the muscle, it breaks up into many collaterals which, in the mammalian limb, supply from 100 to 160 fibers. The motor neuron, with the regiment of muscle cells it supplies, is called a "motor unit". It is easy, therefore, to see that the destruction of a single anterior-horn cell will put out of commission a small group of muscle cells. If one anterior-horn cell were destroyed and its immediately adjacent anterior-horn cell were not involved, then one would expect to find in the muscle a patch of relatively normal cells. Such is the picture presented in Figures 1, 2, 3, 6, and 7.

Figure 2 (N. O. N.) shows fairly good-looking muscle cells below, while at the top of the picture there are cells undergoing a marked degree of atrophy. Note here the diminished size of the cells, in some areas beginning granular change, and the apparent increased number of muscle nuclei, which is a typical picture of cellular atrophy in a moderately advanced stage.

Figure 3 (E. S.) shows relatively normal-looking muscle cells below, but above there is a patch which is being replaced with fibrous tissue. These cells in the upper group have already undergone the changes of atrophy and degeneration, and the fibrous replacement change is now present.

These photomicrographs probably represent the most common finding in poliomyelitic muscles. The explanation is, of course, that certain "motor units" are involved whereas others are not, and this seems to be the rule rather than the exception in poliomyelitic muscles.

Figure 4 (B. F. D.) shows a cross section of a muscle from a child whose history indicated an immediate, complete paralysis with not one degree of function ever recurring in the muscle. The muscle immediately became atrophied and thin, and never during the course of the three-year period following the paralysis did it ever regain any strength or contractile power. Gross examination of this muscle found a uniform fibrous-replacement change throughout.

The microscopic changes noted in Figure 4 show a most marked degree of muscle replacement of the fibrous type. There are a few muscle cells remaining, but they are exceedingly small and atrophic. There is a great increase in interfascicular fibrosis, and fibrous replacement is occurring in the bundles themselves. This picture represents the complete end stage of fibrous replacement in a muscle completely paralyzed. This child's muscle in all probability could never gain in strength because of the apparently complete degree of motor-neuron involvement, and it could not be hoped that treatment of any kind would bring back this muscle's contractile power.

Figure 5 (V. M. S.) is of a section removed from a tibialis anterior in a child whose only residual involvement following an attack of infantile paralysis was a slight equinus and a stretched-out tibialis anterior that graded "fair plus".

The muscle grossly showed almost normal-appearing cells in the

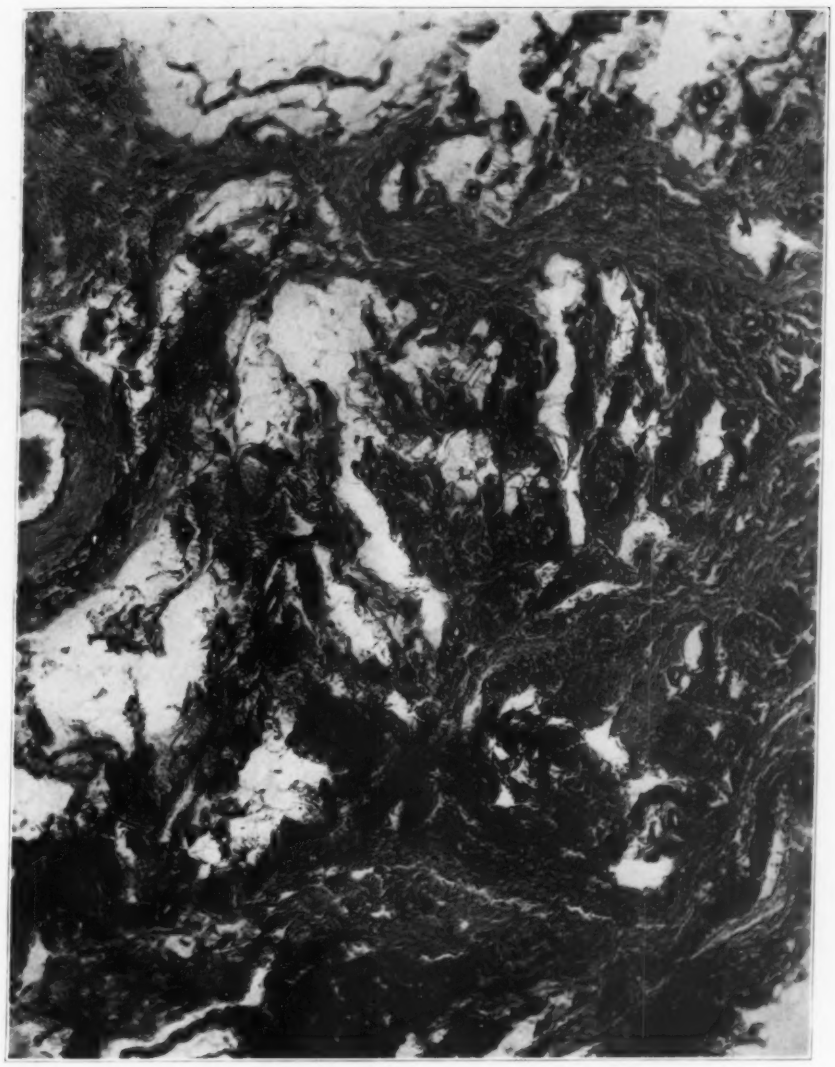

FIG. 4

B. F. D. Muscle grade was zero. Photomicrograph (× 1000) shows stage of complete fibrous replacement,—an end stage in the atrophic, degenerative, replacement process that occurs in a poliomyelitic muscle. A few small atrophic muscle cells can be found, but these are few in number.

upper two-thirds of its belly, but at the musculotendinous junction there was a zone of pale grayish-pink muscle which did not have the contractile power of the upper segment. The microsection is from the lower grayish-pink zone.

This is a most interesting section, as it is a picture also frequently seen in poliomyelitic muscle. This is a zone of fibrosis cutting across muscle cells on longitudinal section and thus interrupting their continuity.

FIG. 5

V. M. S. Muscle grade was fair plus. Photomicrograph (× 1000) shows zone of fibrosis cutting directly across fairly good-looking muscle cells. This is not interfascicular fibrosis. This zone probably interferes with the flow of contraction through the muscle.

Obviously this is not interfascicular fibrosis, as it cuts directly across muscle cells. It is, therefore, most likely that a minute tear or rupture has occurred in the muscle at this point and fibrous tissue has filled in along that zone. There is no other explanation for its presence that is at all reasonable.

Since this photomicrograph is of a section from the most damaged part of a stretched-out muscle, it seems most reasonable to assume that this pic-

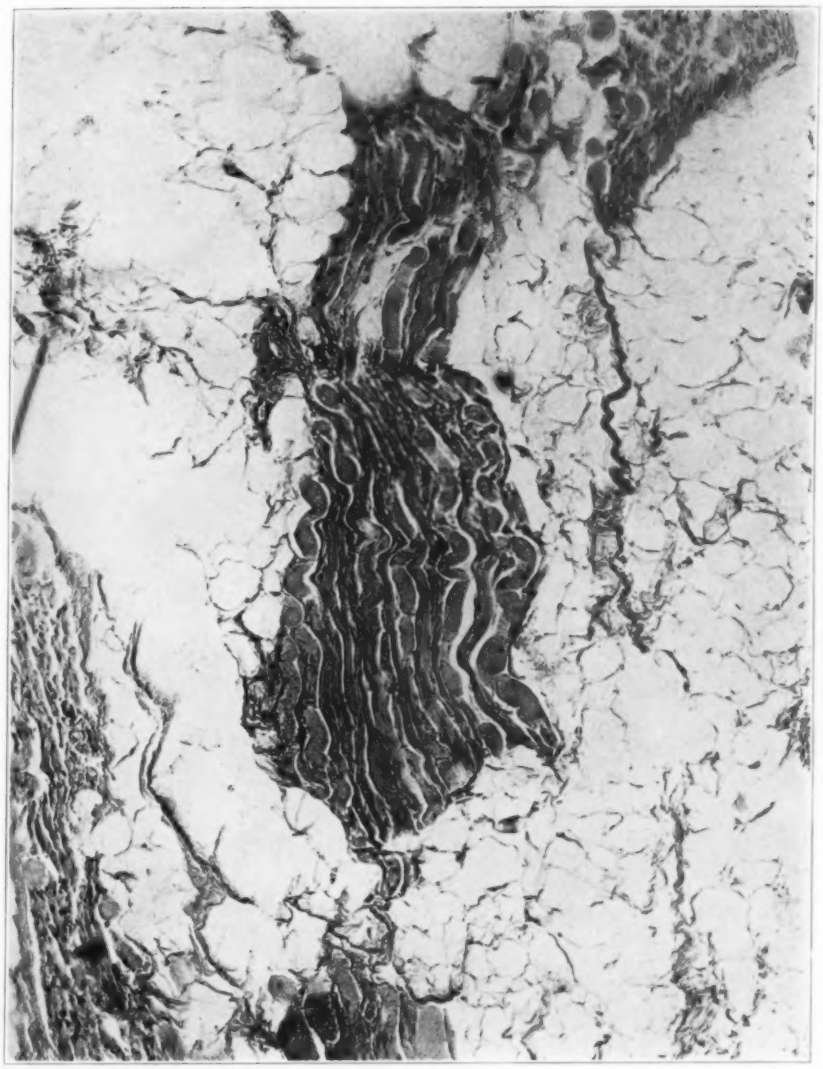

FIG. 6

M. M. Muscle grade was zero. Photomicrograph (× 1000) shows muscle that is being completely replaced by fatty tissue. This also is an end stage, but the replacement tissue is predominantly fatty instead of fibrous. The cells of this island are undergoing various degenerative changes. Note the swollen fibers that show the mealy, waxy change of beginning disintegration.

ture represents what may happen to a poliomyelitic muscle when subjected to a too great and too prolonged stretch. This zone then is a "stretch tear" which occurred in multiple areas through the lower zone of the muscle. No gross, sudden, severe injury or rupture occurred, but the slow, continued stretch force produced multiple microscopic tears in the muscle.

Naturally the presence of these transverse zones of scar tissue weaken a muscle. They, themselves, delay the flowing wave of contraction

FIG. 7

B. R. G. Muscle grade was poor. Photomicrograph (× 1000) shows muscle island surrounded by fatty change. Note the fat cells replacing muscle fibers. In some places fat-cell nuclei (signet-ring appearance) can be seen. The cells in the island are undergoing atrophy, and a few are showing beginning hyalinization.

through the muscle, and the original tear damaged not only the muscle cells directly torn, but also, axon collaterals to other cells beyond the damaged zone.

This illustration, therefore, rather concretely shows one of the *secondarily* induced pathological changes which may occur in muscle after the acute paralysis is over, and reemphasizes the clinical importance of preventing a stretch of involved muscles.

It is also probable that the occurrence of such things as this will ex-

plain the continued soreness and tenderness in some poliomyelitic muscles long after the acute stage is over.

Figures 6 (M. M.) and 7 (B. R. G.) are sections similar, in that minute muscle islands remain in a sea of fat. Both muscles are extremely weak, and pathologically show an end stage of fatty-replacement change.

The most logical explanation for the presence of muscle islands like these is that they represent intact "motor units". It is not so likely that they are more hardy cells which thus far have survived the degenerative, disintegrative, and replacement changes that progressively occur in denervated muscle.

Previous work [2, 3, 4, 5, 9, 10, 18, 20, 22, 24, 25] on denervated muscle, experimentally produced, has always found a rather uniform or homogeneous degree of pathological change throughout all parts of the involved muscle. Since this has not occurred here, and these muscles have been paralyzed for a sufficiently long period of time, it is most likely that this represents a remaining "motor unit".

There are, however, pathological changes occurring in these island cells, but of a very much earlier stage. These latter changes, therefore, must be changes secondarily induced.

Since this is most likely true, then an analysis of the physiological status of these islands should lead to some positive information in regard to these secondary changes—why they develop, their progress, and perhaps point out some way of preventing their occurrence.

Physiologists have long demonstrated that a muscle remains, even in its relaxed, resting state, in a constant tension [19, 23]. This tension is absolutely necessary for the proper function of that muscle; and if that tension is lost, the muscle cannot function at all. It cannot contract, since it has already contracted maximally and the fibers are as short as they can possibly be. This, of course, induces a complete and unnatural rest or state of disuse in the muscle, which, as many authors have shown, causes a severe degree of atrophy to occur.

Lippmann and Selig showed that the degree of atrophy in a muscle following tendon section was most complete, and of about the same degree as the atrophy of denervation. The cells in the muscle islands are in the same physiological status as those of a muscle completely relaxed by having its tendon cut. These cells remained stretched-out in their normal tension for some time following the paralysis,—being held so, by the surrounding, still intact, but denervated muscle cells. Atrophy and disintegrative changes, however, occurred in these surrounding cells due to the denervation, and fatty tissue replaced them. This fatty tissue, being loose and flaccid and surrounding these islands, did not maintain the tension necessary for normal function in those island cells. They, therefore, gradually contracted as fatty replacement occurred, and now they are in a stage of complete disuse, just as is a muscle with its tendon completely cut; hence atrophy and subsequent degenerative changes are occurring. These are, therefore, *secondarily* induced changes, due to the position and

tension status of the island cells and not due to involvement of the anterior-horn cells.

In these muscles (Figs. 6 and 7), therefore, two different groups of pathological events are occurring. The primary or initial chain of events is due to denervation and is almost completed. Muscle cells following denervation underwent atrophy, degeneration, and disintegration; and then fatty replacement occurred. Remaining uninvolved "motor units" are affected also by the loss of these denervated cells, since the tension status of the remaining cells is altered. This change in tension, which is so important a part of normal muscle function, thus induces secondary pathological changes in the remaining cells.

The final weakness or strength of an involved muscle, then, is the summation of these two pathological processes.

A general comparison of the sections from all the ninety-four examined muscles was made. This revealed the following:

1. The age of the patient seems to have no bearing on the microscopic picture of any muscle.

2. The muscles showing fatty-replacement changes are uniformly weaker muscles than those showing fibrous-replacement changes.

3. Fifty per cent. of the muscles examined showed cellular hypertrophy in involved bundles.

4. Sections showing cellular hypertrophy almost invariably were from muscles grading "poor" or better. Only one graded "trace" and none "zero".

5. No newly formed or regenerating muscle cells were found in any section.

Some authors [12, 16, 17] in writing on poliomyelitis have mentioned the presence of newly formed muscle cells. They explain a gain in muscle strength through cellular regeneration.

A careful thorough study of every section from every muscle was made, and it failed completely in finding any evidence of new muscle cells. Sections from the muscles of very young children, in whom an actual regrowth of new muscle might be most reasonably expected to occur, if it could occur at all, failed completely in locating anything resembling newly formed or regenerating cells.

It seems, therefore, that physiotherapy and exercise can only conserve and develop the strength in the remaining cells of a partially paralyzed muscle, and cannot increase strength by inducing new cells to form.

The early treatment which the involved muscles received in each case was reviewed. This revealed the interesting fact that those muscles showing fatty change were muscles which had been immobilized or not used for long periods of time. Muscles showing a predominance of fibrous change were in patients who had tried to walk or stand early or had exercised their muscles vigorously.

Naturally, conclusions drawn from this observation cannot be scientifically correct, because of so many unknown and interrelating

factors in each case; yet, it does suggest that prolonged inactivity is harmful and probably induces fatty-replacement change following the atrophy of disuse. Since muscles showing fatty change are uniformly weaker than those showing fibrous change, it seems logical to theorize that prolonged inactivity does more harm to a muscle than too vigorous activity.

GENERAL DISCUSSION AND CONCLUSIONS

Microscopic evidence seems to indicate rather conclusively that a gain in strength by a partially paralyzed poliomyelitic muscle does not occur through the formation of new muscle fibers, but through an overdevelopment or hypertrophy of remaining undamaged cells.

Pathological changes occurring in muscle following acute anterior poliomyelitis are brought on in two ways:

1. *Primarily*, through denervation.
2. *Secondarily*, from abnormal variations of tension in the muscle.

The cellular changes from denervation begin with atrophy and progress to degeneration, disintegration, and replacement changes. These same pathological stages occur in muscle cells in exactly the same way, due to secondary factors. Too much tension or overstretching results in minute tears, zonal degeneration, and subsequent fibrosis; while too little tension produces changes identical with denervation, and the rate of change is nearly as fast. These secondary abnormalities may produce just as much weakness in a muscle as the primary denervation changes.

Secondary changes following immobility and disuse seem to be more severe than those following overactivity.

Obviously, there is nothing much that can be done for muscle cells which have lost their motor neurons and have undergone or are undergoing these regressive changes. Something might be done, however, about the secondary changes which occur.

The knowledge, therefore, that these secondary changes do occur and how they occur should be of some practical value in planning treatment for postpoliomyelitic muscles.

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THE USE OF PRESERVED BONE GRAFT IN ORTHOPAEDIC SURGERY *

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Two years ago, the author had the honor of presenting to this Academy a preliminary report † on his personal experience with the use, for grafting purposes, of homologous and autogenous bone, preserved in citrated blood and kept under refrigeration, especially as a surgical aid in the treatment of ununited fractures of the neck of the femur.

Since that date, he has been using this procedure in those patients in whom the operative risk was so high that bone-grafting performed in a single operation would considerably endanger the life of the patient, or in those in whom it was thought inadvisable to use autogenous bone because of the extreme difficulty in its acquirement, the risk of infection, or the poor osteogenetic power of the bone which was obtainable.

Thirty-six patients are now reported in whom the author has used refrigerated bone as grafting material. Through the courtesy of Dr. P. Sanchez Toledo, it is possible to add sixteen more cases which were treated by him according to this technique, making the total number of cases reported fifty-two.

In forty-three of the patients operated upon, the graft was obtained from the same patient; in eight patients, homologous bone obtained from a donor was used; and in one, bone from a nine-months foetus was employed.

The conditions for which preserved bone grafts have been used are shown in Table I.

TABLE I

CONDITIONS FOR WHICH PRESERVED BONE GRAFTS HAVE BEEN USED

	No. of Cases
Blocking of paralytic foot	3
Ununited fracture of the patella	1
Ununited fracture of the neck of the femur	12
Spine fusion (Pott's disease)	16
Pathological fracture of the neck of the femur (bone cyst)	1
Recent fracture of the neck of the femur	8
Paralytic scoliosis	4
Platyspondylisis	1
Idiopathic progressive scoliosis	4
Spondylolisthesis	1
Epiphysitis of the femoral head	1
Total	52

* Read at the Annual Meeting of the American Academy of Orthopaedic Surgeons at New Orleans, Louisiana, January 15, 1941.

† Not published.

Different types of grafts which have been used to comply with the purpose of the operation are given in Table II.

TABLE II
TYPE OF GRAFT

	No. of Cases
Massive solid	36
Osteoperiosteal	1
Mixed, solid, and osteoperiosteal	13
Epiphyseal	1
Foetal massive	1
Total	52

The source of the graft is shown in Table III.

TABLE III
SOURCE OF GRAFT

	No. of Cases
Humerus	1
Tibia	45
Fibula	2
Ribs	1
Head of the astragalus	2
Femur and tibia (foetal)	1
Total	52

The bone obtained for grafting purposes has been preserved by placing it in a sterilized glass container, covering it well with citrated blood from the patient or from a donor of the same blood group, and immediately placing it in a refrigerator at a temperature fluctuating between 2 and 5 degrees centigrade. In some cases, normal saline solution, or saline solution to which has been added a small amount of blood from the patient, has been used for this purpose.

TABLE IV
FORM OF PRESERVATION

	No. of Cases
Citrated blood	34
Saline solution	1
Saline solution and blood	17
Total	52

The time period in which the graft has been preserved has varied in accordance with the circumstances of each case.

The possibilities of autogenous and homologous bone transplantation have been known for years, and the author has profited from the experience and magnificent work of such men as Murphy, Lexer, Carrel, Albee, Delbet, Tuffier, Haas, and many others, who by their experimental and clinical work have argued and proved the superiority of the autogenous bone graft over the homologous and heterologous transplant. The author agrees entirely with the generally recognized superiority of autogenous bone.

In some cases, however, autogenous bone is difficult or impossible to obtain, and even homologous bone at times is not obtainable from a living

subject at the moment at which it is needed. When large massive transplants are necessary in order to perform both operations at the same time, they are very seldom obtainable. Lexer in his transplantations used amputated limbs while "still warm", but in very few instances can a surgeon find a freshly amputated limb.

TABLE V

TIME PERIOD OF PRESERVATION OF BONE GRAFTS

3 days	3 cases
4 days	2 cases
5 days	1 case
7 days	15 cases
8 days	4 cases
10 days	4 cases
12 days	2 cases
14 days	9 cases
15 days	3 cases
18 days	3 cases
19 days	1 case
21 days	2 cases
24 days	1 case
35 days	1 case
63 days	1 case
Total	52

There are reported in the literature rare instances of successful homoplastic bone transplantations, as in the cases reported by Ellmer and Schmincke, Calvé, Leriche, and others, and even transplantations of joints by Lexer, Meyer, and others. There have often been reports of bone transplanted from mother to son, or from brother to brother. On the other hand there have also been failures following the use of homoplastic bone and of cadaver bone as a transplant.

Until recently, because of difficulties created by sentimental and religious prejudice, it has been impossible to obtain bone for preservation from fresh cadavera. On one occasion the author was able to use preserved foetal bone for spine fusion in a small child. However, the experimental and clinical work of Carrel, Tuffier, Lexer, and others, on the viability of bone and other tissues obtained from the fresh cadaver and refrigerated for varying periods of time, and the work of Youdine and other Russian investigators concerning the use of cadaver blood for transfusion indicate that the acquirement and preservation of such bone and its use for grafting purposes is feasible.

TECHNIQUE

For the last six years, the author has used autogenous or homologous preserved bone for grafting purposes. This has been obtained aseptically through a surgical operation, and kept well covered and surrounded by citrated blood of the patient or donor, refrigerated at an average temperature of 37 to 40 degrees Fahrenheit, and bacteriologically controlled during the period of preservation.

FIG. 1

Histological aspect of bone twenty-one days after preservation in citrated blood under refrigeration.

To prove the viability of the bone kept under the above-mentioned conditions, some experimental work has been carried out, consisting of a number of operations performed on rabbits and dogs. These have been sufficient to prove that bone, kept under the previously described conditions, could be transplanted from one animal to another without any local or general reactions, and in those cases where primary healing was obtained, would act like any fresh autogenous bone, even though it had been kept for three weeks before being used for grafting.

The histological aspect of bone preserved under the same circumstances for different periods of time has also been studied for variations of the staining properties of the bone cells, which could indicate necrosis. The bone cells and bone tissue vary little or not at all from preparations of fresh bone. Only in places where trauma has produced sloughing or separation of the tissues and in the medullary tissue is there any necrosis.

The third and most important proof of the viability of a refrigerated bone transplant is the clinical evolution of the graft. As a convincing demonstration of the preservation of the so-much-discussed biological properties of the bone graft, the author presents as undeniable clinical facts two patients with non-union of the neck of the femur and almost complete absorption of the central portion of the neck, in whom refriger-

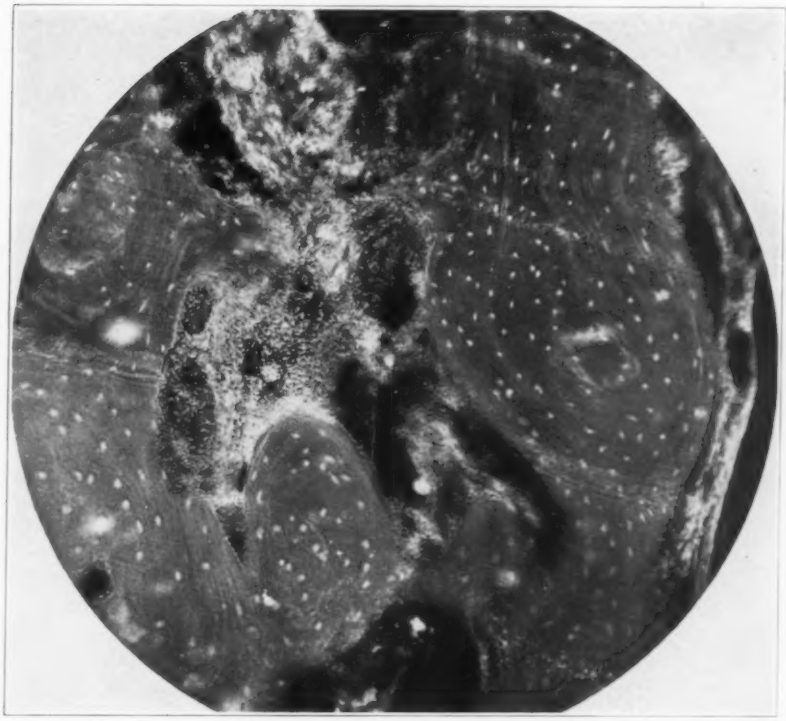

FIG. 3
Histological aspect of bone 105 days after preservation.

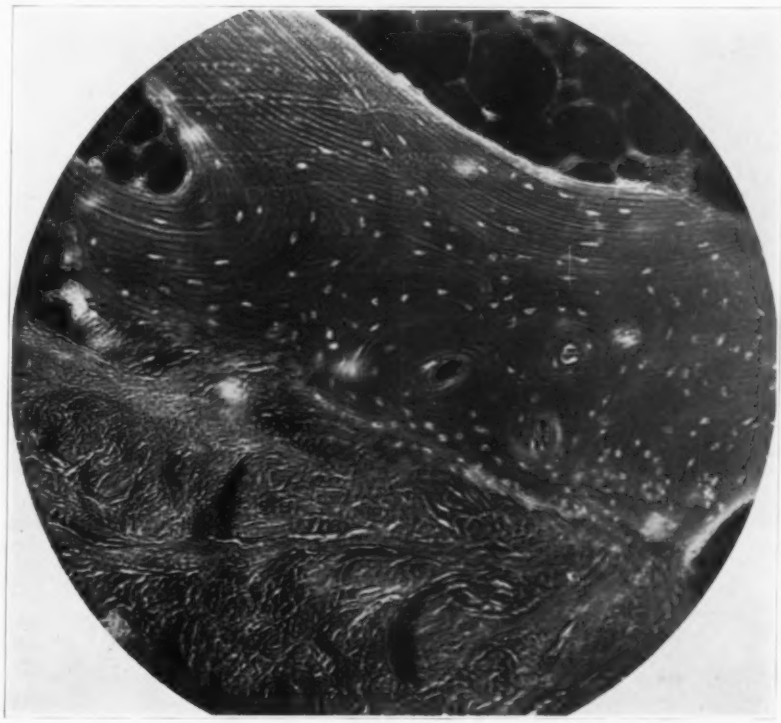

FIG. 2
Histological aspect of bone twenty-eight days after preservation.

FIG. 4-A

Case 1. Old ununited fracture of the neck of the femur with marked absorption of the central portion of the neck.

FIG. 4-B

Case 1. Anteroposterior view after operation. Mechanical fixation with a Smith-Petersen nail. Biological treatment with refrigerated autogenous bone filling the gap between the head and the trochanteric part of the neck.

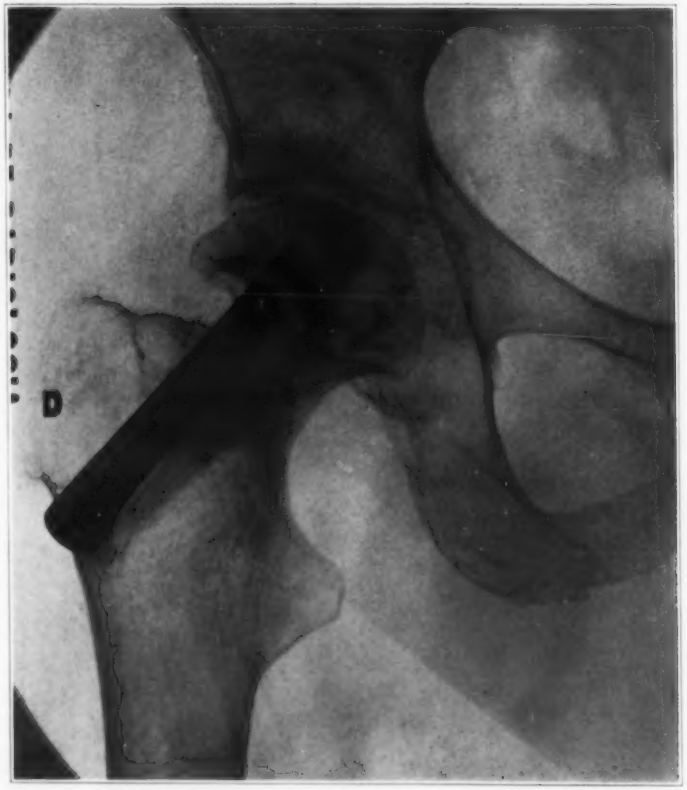

FIG. 4-C

FIG. 4-D

Case 1. Anteroposterior and lateral views showing the result one year after operation. Complete restoration of the neck through the graft has taken place, but the gap persists in the upper aspect of the neck where the bone graft was not used.

FIG. 5-A

Case 2. Ununited fracture of the neck of the femur with marked absorption.

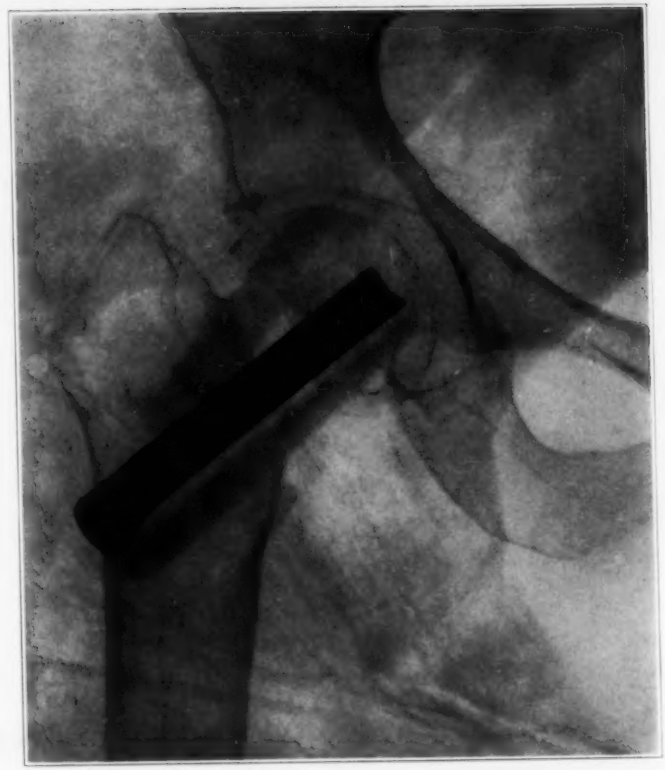

FIG. 5-B

Case 2. Mechanical fixation with a Smith-Petersen nail, and biological treatment with two autogenous bone grafts which had been kept in citrated blood under refrigeration for ten days.

FIG. 5-D

FIG. 5-C

Case 2. Anteroposterior and lateral views showing result one year after operation. There is restoration of the neck and perfect function.

FIG. 6

Lateral view of a postmortem specimen after a spine fusion with preserved bone.

ated bone grafts have been used as a bridge between the atrophic head and the trochanteric part of the neck. Clinical and roentgenographic examinations of these patients at different periods have shown that union has been obtained through the graft, and that reconstruction of the neck has resulted from new-bone formation, but only in the region where the graft was placed. A postmortem specimen (Fig. 6), showed that a solid bony fusion had been obtained in a case of Pott's disease. Refrigerated bone had been employed, and had acted as any fresh transplanted bone would in an operation of this type.

As has been stated before, the preserved bone graft is not intended to displace fresh autogenous bone as the best obtainable material for grafting purposes, but the author is sufficiently satisfied with the behavior of preserved bone to recommend its use when conditions and circumstances demand.

INDICATIONS

The autogenous preserved bone graft has been reserved exclusively for patients needing bone transplants in whom the high operative risk has made the two-stage operation the method of choice. When for any special reason—such as syphilis, tuberculosis, bone atrophy due to previous immobilization of long standing, or endarteritis obliterans leading to previous amputation—the acquirement of bone from the patient could not be recommended, homologous bone obtained from a voluntary donor has been used for this purpose.

In cases of non-union of the neck of the femur, the bone-graft-peg operation originally described by Albee seems the method of choice.

Fig. 7-B

Fig. 7-A

Anteroposterior and lateral views of a fracture of the neck of the femur showing the biological and mechanical treatment by the use of a four-flanged nail carrying a tunnelized bone graft. This nail has been developed by Dr. U. Sosa.

FIG. 8

Spine fusion for paralytic scoliosis with massive preserved bone graft.

Because of the advanced age and poor general conditions prevailing in many of these patients, implantation of the bone graft and suturing of three operative wounds in a single surgical procedure has been considered by most orthopaedic surgeons a major and risky operation.

In the author's technique, bone from the tibia of such a patient is obtained, under local anaesthesia, and is preserved in the manner described for a period of from seven to fifteen days. Then in a second operation, also under local anaesthesia, the displacement of the fragments is reduced. Through a small incision in the trochanteric region the neck and head of the femur are drilled and, under roentgenographic control, the bone peg is properly implanted. There has been no mortality due to the operation in any of these cases. For this reason the author has adopted this technique for the treatment of ununited fractures of the neck of the femur, using in his last eight patients, as a mechanical means of fixation, the Smith-Petersen nail, placed parallel and immediately above the bone graft.

The author is convinced that, in the treatment of recent fractures of the neck of the femur, the necessary restoration of the biological conditions indispensable for bone repair are not always obtained by the conservative treatment or by the surgical fixation with nails, screws, bolts, etc. For this reason, in the last group of patients with a subcapital or transcervical fracture of the neck of the femur the author has recom-

mended the early use of a bone graft, combined with the use of internal fixation by a Smith-Petersen nail. The bone transplant is resected under local anaesthesia, and is preserved. The patient is treated by traction in a Braun frame, and is checked by the internist before the operation is done. There has been no mortality so far in the eight patients subjected to this treatment, although two of them are close to or over ninety years of age.

In five cases of recent fracture of the neck of the femur, a special vitallium nail developed by Dr. U. Sosa, has been used. (See Figures 7-A and 7-B.) It carries a tunnelized bone graft, and aims to solve both the problem of mechanical fixation of the fracture and the biological problem of impaired circulation.

Spine fusion, for the treatment of Pott's disease or for the fixation of a previously corrected paralytic or structural scoliosis, or for any other condition of the spine in which fusion of a number of vertebrae is indicated, has been in the author's practice a procedure frequently attended by shock. This is especially true in children in whom, because of preexisting anaemia, intestinal parasites, and liver insufficiency, operations of this type are considered to be extremely dangerous. Twenty-six of the fifty-two operations were spine fusions. The necessary bone for an extensive fusion was obtained from the patient or from a donor in a previous operation under local anaesthesia. When massive solid grafts are employed, a flexible probe is molded over the spinous processes shown in a lateral roentgenogram of the spine, to give the size and shape of the grafts required.

It is interesting to compare the temperature, pulse, and respiration of five patients in whom spine fusion was done in a single operation with those in five patients in whom either autogenous or homologous preserved bone grafts were used for spine fusion (Fig. 9). In most of the patients in whom this method has been employed, blood transfusion has been unnecessary, and shock and dehydration have been easily controlled. There has been no mortality due to the operation itself.

RESULTS

In fifty-two patients in whom preserved bone grafts have been used for different purposes, the final results have been checked in forty-three, or 82.7 per cent. of the total number. In thirty-two, or 74.4 per cent., of them, the end results were excellent or good, while in ten, or 23.3 per cent., they were poor or failures. The only death immediately after operation was due to uraemia, one month after fixation of a recent fracture of the neck of the femur.

It is very interesting to review the results obtained in the different conditions for which preserved bone was employed. For blocking purposes in paralytic drop-foot, the results have been good in every case. In ten cases of ununited fracture of the neck of the femur, bony union was obtained in nine. In two of these patients a complete regeneration of the

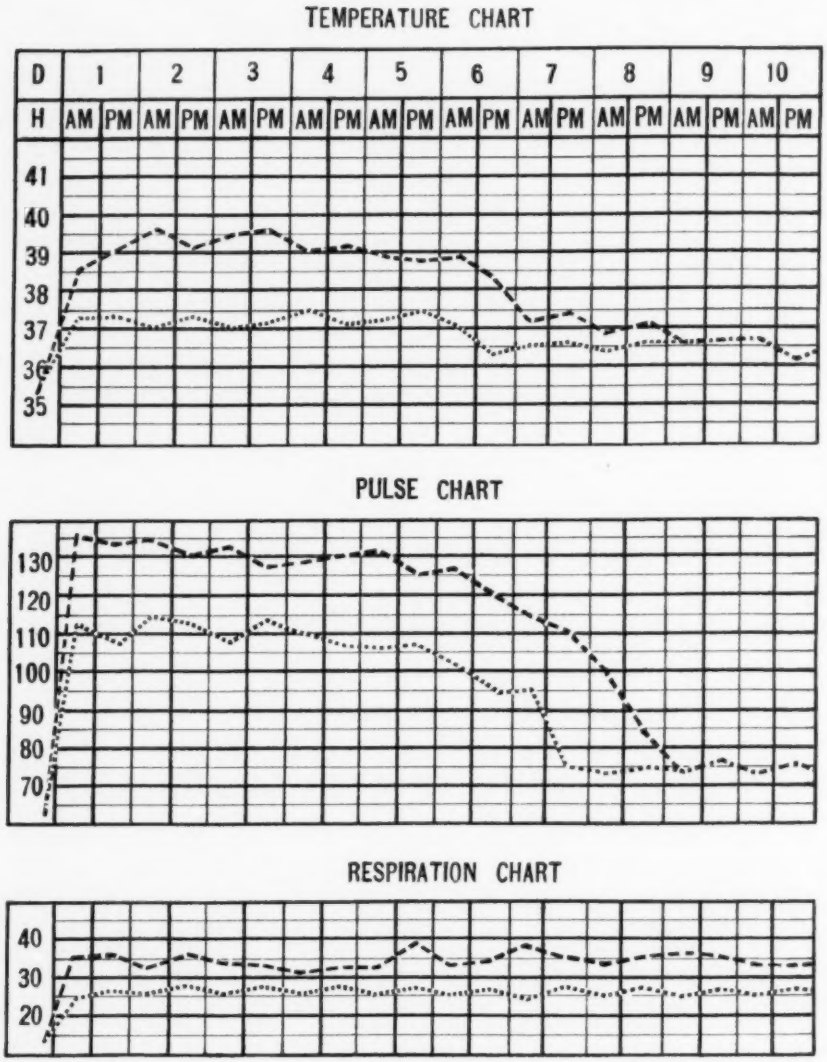

FIG. 9

A comparative study of the postoperative temperature, pulse, and respiration rates.

Dashed lines show the averages of five patients in whom spine fusions had been performed in a single operation, using fresh autogenous bone grafts.

Dotted lines indicate the averages of another five patients in whom spine fusions had been performed, using preserved autogenous or preserved homologous bone grafts.

Note the marked differences in the two groups.

neck which had absorbed has been produced by the bone graft. In connection with ununited fractures of the neck of the femur, it is of note that inveterate untreated syphilis has been a serious handicap and a cause of failure. The functional results in those patients in whom a bone graft was used in combination with a Smith-Petersen nail have been much better than in those in whom plaster was used for immobilization.

The end results in recent cases of fracture of the neck of the femur have been less satisfactory than those obtained in ununited fractures. Union has been obtained in 67 per cent. of the small series of patients operated upon. It must be emphasized that in five of the patients operated upon the graft-carrying nail has been used, and in only three patients have the massive graft and nail been employed.

It is very encouraging that no operative mortality has resulted from twenty-six spine fusions performed in two stages with preserved bone. In twenty of these patients the end results were checked a year or more after the operation. In sixteen, or 80 per cent., the graft has acted as any fresh bone graft would, and spine fusion has been obtained. The postoperative course in those cases has been extremely satisfactory.

Of forty-three patients in whom autogenous preserved bone has been used, final results have been checked in thirty-four. In twenty-four, or 70.6 per cent., of them the results were considered good. In two, the results were fair, and in eight, or 23.5 per cent., the operation failed.

In eight patients, homologous preserved bone was used. In six patients, or 75 per cent., the results were good; in one, the result was fair; and in one, a failure.

In the only case in which foetal bone was employed, fusion of the spine was obtained.

CONCLUSIONS

Autogenous or homologous preserved bone has been used for the treatment of several conditions in which bone-grafting was indicated, and has acted like any fresh bone in similar use.

In patients for whom the operative risk is great, or in patients from whom fresh autogenous bone is not obtainable, homologous preserved bone can be used successfully. In the fusion of numerous vertebrae, especially in small children, a two-stage operation, using preserved bone grafts, has greatly diminished the incidence of postoperative complications, and has eliminated mortality.

In ununited and fresh fractures of the neck of the femur, the preserved bone graft can be recommended, either alone or associated with a Smith-Petersen nail.

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VALGUS DEFORMITY OF THE KNEE RESULTING FROM INJURY TO THE LOWER FEMORAL EPIPHYSIS *†

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In growing children injury to the epiphyseal cartilage plate of the lower end of the femur may cause a severe valgus deformity with functional shortening of the leg and an extreme degree of angulation. Its treatment constitutes a difficult problem for the orthopaedic surgeon. In this paper five cases of special interest are reported. One patient was seen at the time of the initial injury, so that it was possible to observe the development and progression of the deformity. Two were seen during the growth period with the deformity already well marked, and two were observed at the end of the period of growth when the deformed condition was fully developed.

As a result of these studies and this experience in the treatment of these patients the following points will be discussed:

1. The relationship of injury to the development of valgus deformity.
2. The pathogenesis of this deformity with special reference to the degree of angulation produced, the amount of total and functional shortening, and the development of secondary deformity in the tibia.
3. A method for the surgical correction of the deformity.
4. A plan of treatment when this condition is already present and increasing in the growing child.

THE RELATIONSHIP OF INJURY TO THE DEVELOPMENT OF VALGUS DEFORMITY

The femur and tibia are held together at the knee by ligamentous structures with no bony locking mechanism. For this reason, most injuries produce either pure epiphyseal separation in young children, or epiphyseal separation with associated diaphyseal fracture in older children. In a previous paper [1] it was pointed out that in such injuries, the line of separation passes between the calcifying cartilage cells of the epiphyseal plate and the metaphysis. Therefore, the epiphyseal cartilage and its

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blood supply are not necessarily damaged. Clinical experience verifies this fact, as deformity and disturbed growth are very rare, although epiphyseal separation at the knee is not infrequent. Disturbed growth results only from direct trauma to the epiphyseal cartilage plate or to the epiphysis. This type of injury is most uncommon, and in younger children follows crushing injuries, such as those which are due to a fall from a considerable height. In older children fractures of the epiphysis and the cartilage plate may occur in shearing injuries, but such cases are rare.

Several types of deformities have been reported, including absolute cessation of growth, genu flexum, genu recurvatum, genu varum, and genu valgum. The valgus type is the most frequent, because the lateral portion of the cartilage plate is most often crushed. This is due to the normal degree of valgus at the knee, and to the fact that the lateral side of the knee is more exposed to trauma. When injuries are due to a fall, the normal degree of valgus at the knee causes the greatest portion of the weight of the body to strike the lateral condyle; also in shearing injuries, the lateral portion of the plate is most frequently injured. Sometimes in these injuries to the epiphyseal plate, a fracture of the shaft of the femur on the same side also occurs. In the presence of this major injury, the damage to the epiphyseal plate may be overlooked, and its true significance may not be fully realized until deformity of the knee develops. The association of these two injuries is well demonstrated in two of these cases. In fractures of the shaft of the femur in children, especially those caused by falls, careful clinical and roentgenographic examinations should be made in order to rule out the possibility of injury to the epiphyseal plate of the lower end of the femur.

PATHOGENESIS OF THE VALGUS DEFORMITY

The crushing injury destroys the cartilage cells in the lateral portion of the epiphyseal cartilage plate. Healing occurs with the formation of scar tissue and a small bony lock between the epiphysis and the diaphysis. The undamaged mesial portion of the plate continues to grow downward and in a circular direction, with the bony lock as a pivot point, and gradually produces the valgus deformity. The degree of valgus is dependent on the exact location of the bony lock in the epiphyseal plate, and on the age of the patient at the time of injury. In older children who are near the period of cessation of growth, little or no deformity will take place. In young children severe deformity is certain to occur.

The longitudinal downgrowth of the medial condyle is never equal to the growth of the normal side, because the growing portion of the plate is gradually encroached upon by progressive union of the epiphysis to the diaphysis, proceeding from the lateral to the medial side. As a result of this process, the growing portion of the plate always fuses earlier than the corresponding epiphyseal cartilage plate of the normal femur. The actual growth is expended in a circular direction with the bony lock as a pivot point.

Because of these two facts, the amount of longitudinal downgrowth is also dependent upon the position of the bony lock. If the lock is at the exact lateral portion of the plate, the longitudinal downgrowth of the medial condyle is greater for a given growth increment, since the arc of the circle is larger. As more time is taken for the gradual encroachment of the medial side of the plate by the process of fusion, growth continues for a longer period of time. On the other hand, as the lock is removed from the lateral side, the medial side of the plate closes earlier, the arc of the circle is smaller, and the downgrowth of the medial condyle is lessened.

When the medial side of the plate fuses, the degree of deformity is fixed. Continued growth from the distal cartilage of the normal femur increases the relative inequality in length of the two legs.

In addition to the actual loss in length of the femur from the lack of longitudinal growth of the medial and lateral femoral condyles, there is decreased functional length from the degree of valgus of the knee. With increasing angulation the child finds it necessary to walk with the upper leg in more adduction in order to bear the weight upon the foot in both walking and standing. Therefore, the functional length of the leg is not represented by the actual lengths of the femur and tibia, but by a straight line from the femoral head to the medial malleolus. The functional loss of length becomes greater with the increasing degree of valgus according to the trigonometric formula for any triangle.* For this reason, the practical loss in length is always greater than that represented by the loss of growth of the lateral condyle, and much greater than the loss of growth of the medial condyle. This was well illustrated in two of the cases. In one patient with four inches of shortening of the medial condyle and five inches of shortening of the lateral condyle, there was a functional shortening of six inches. In another patient with even greater angulation, only one inch of shortening of the medial condyle was present and only three inches of shortening of the lateral condyle. However, there was six inches of functional shortening.

In children in whom the angulation is severe and has developed since early childhood, a compensatory deformity in the opposite direction is found in the tibia. This deformity or bending is in the region of the epiphyseal cartilage plate of the tibia. In two such cases no evidence of loss of growth or of compensatory overgrowth was found. This deformity is not due to disturbed growth, but to a bending of the bone in a varus direction, due to the faulty weight-bearing stresses produced by the valgus deformity of the femur.

The development of the femoral articular surfaces is not intrinsically disturbed by this deformity. It is the plane of motion in relation to the shaft of the femur which is altered. For this reason the range of motion

* $(a^2=b^2+c^2-2bc\ (cos\ A)$, where a equals the functional length, A the degree of angulation, b the length of the femur from the head to the medial condyle, and c the length of the tibia from the medial condyle to the medial malleolus.

at the knee is normal. The muscle pull, however, exerted across the angulation is abnormal, and tends to displace the patella laterally. In one patient with severe angulation, the patella was displaced from the trochlear notch laterally into the angle formed by the femur and the tibia. All the soft structures on the lateral side of the thigh were relatively short in relation to the structures on the medial side. The peroneal nerve was likewise relatively short. These facts must be borne in mind in the consideration of operative correction. Laxity of the external lateral ligament has been observed in all of the cases of severe deformity. It is felt to be due to an attempt on the part of the patient to adduct the lower leg upon the femur in order to bear weight upon the foot while walking.

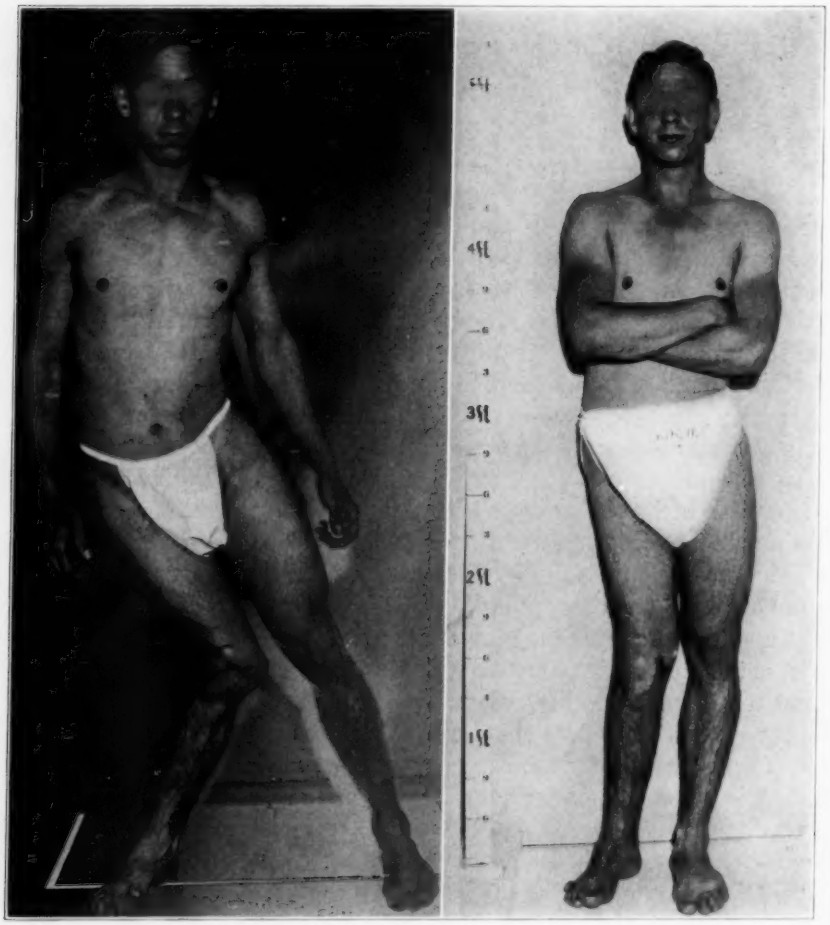

FIG. 1-A FIG. 1-B

Fig. 1-A: Case 1, A. I. Photograph showing the deformity before operation. Note the markedly adducted position of the thigh with the functional shortening.

Fig. 1-B: Photograph showing the correction obtained by excision of the medial condyle. The functional result was poor, because of limitation of motion at the knee.

THE SURGICAL TREATMENT OF VALGUS DEFORMITY

The purpose of surgical treatment of the far-advanced deformity is to secure complete correction with as much increase in the length of the leg as possible. The normal function of the knee should be maintained. Any residual inequality in the final length of the legs may subsequently be eliminated by leg-shortening or leg-lengthening operations.

In one patient a hemiarthroplasty was performed with excision of the medial condyle of the femur. The cosmetic result was good, but the functional outcome was very poor, because the motion of the knee was markedly restricted.

CASE 1. A. I., sixteen years of age, entered the hospital on June 17, 1935, for the correction of a severe valgus deformity of the right knee.

At the age of eight years, he was struck by an automobile and received a laceration at the lateral side of the knee. Infection apparently developed, because drains were placed in the wound. No roentgenograms were taken. One year after the accident a knock-knee deformity developed, which gradually increased in severity. The boy's gait became awkward, and, to compensate for the knock-knee, he held his hip in marked adduction (Fig. 1-A).

Examination revealed an extreme prominence of the medial condyle of the right femur. The leg was held at an angle of 45 degrees on the thigh, and a functional shortening of six inches was present. Although the patella was displaced laterally from the trochlear notch and contractions of the quadriceps muscle tended to increase the valgus deformity, the motion of the knee was good.

Comparative measurements taken from teleoroentgenograms revealed a loss of growth of three inches from the tip of the greater trochanter to the lateral epicondyle.

Operation was performed in two stages. On June 28, 1935, the soft structures on the lateral aspect of the knee were lengthened. On August 7, 1935, a part of the internal condyle of the femur was removed to permit a more complete correction of the deformity. The denuded surface of the condyle was covered with fascia lata. A low-grade infection followed operation, and there was drainage from the wound. Weight-bearing was begun ten months after the second operation.

The functional result in this case was unsatisfactory, because of painful and restricted motion of the knee joint (Fig. 1-B).

The oldest surgical procedure for the correction of a valgus deformity of the knee is a transverse osteotomy about three to four inches above the condyles of the femur, after which the leg is bent inward. This had been done very early in one of the patients (Case 5). In modern times the chief recommendation of this operation is its simplicity. Only fair reparation is accomplished, and an outward bowing of the thigh is produced, which may persist for a considerable length of time. Functional length is gained, but not as much as by other types of osteotomies to be later described.

A low oblique osteotomy, just above the epicondyles, allows correction at the site of the deformity, but unlike the higher osteotomy does not cause another deformity in the opposite direction at a higher level. This procedure may be varied in two ways. A triangular section of bone with its base facing inward may be removed from the medial side of the femur. This constitutes the well-known cuneiform osteotomy. The osteotomy may be performed at the same level, but wedged and held open on its

lateral side with a triangular section of bone usually taken from the ilium; this procedure is termed the open-wedge osteotomy. Increased functional length is obtained with either type, but the open-wedge osteotomy, by bringing the lateral condyle down to the level of the medial condyle, provides the greater length. The most satisfactory results are obtained in those cases where the details of procedure are carefully outlined in advance. This necessitates consideration of the type of osteotomy, the quality of the bone graft, the lengthening of the soft structures, and the required bony fixation. The possibility of postoperative lengthening must be borne in mind, and preparation made for this eventuality. In every case, tracings should be made from teleoroentgenograms of both femora and tibiae. These will reveal the absolute shortening of the bones, the functional shortening of the entire limb, the degree of valgus deformity, and the presence of compensatory deformity in the tibia. The site and type of osteotomy necessary for correction may be decided upon from these diagrams. By this means, a very good estimate of the expected gain in length can be obtained. As mentioned earlier, it is felt that a low oblique osteotomy, passing through the site of the deformity, if wedged open on the lateral side, will bring the lateral condyle down to the level of the medial condyle and give added length to the femur. When compensatory deformity is present in the tibia, full correction of the femoral deformity, even though resulting in a bowing of the lower leg, is desirable, because correction of the tibial bow will give additional functional length. The tibial osteotomy is similar in nature to the femoral one,—that is, a high oblique osteotomy wedged open on the medial side.

The surgical approach should be sufficiently long to give full exposure of the structures on the lateral aspect of the thigh and knee. The deep fascia may be incised in a long J-shaped incision, curving slightly below the patella. In the patients with marked lateral displacement of the patella, the quadriceps expansion may be similarly cut and freed from the lateral intermuscular septum. The biceps tendon is cut in a Z fashion, so that it may later be sutured in a lengthened position. The greatest obstacle to full correction is the peroneal nerve; to gain as much length as possible, this structure must be dissected free along its course in the lower thigh and especially from the bicipital fascia which binds it down upon the neck of the fibula. The lateral intermuscular septum should be cut from the lateral epicondyle, and stripped up as high as the site of the osteotomy. The lateral head of the gastrocnemius is freed from the posterior aspect of the lateral epicondyle.

The site of osteotomy is exposed by forward retraction of the vastus lateralis. The periosteum is elevated and the soft structures protected with Bennett retractors. The osteotomy is best performed with the Cayo saw, particular attention being paid to sectioning of the bone at the predetermined site. To allow for postoperative fixation of the fragments, the bone is cut a little higher across the lateral epicondyle, thus producing a small ledge on the lateral aspect of the distal fragment after it is rotated

around and downward. The osteotomy is then wedged open as far as possible without too much stretching of the peroneal nerve. Moderate relaxation of this structure may be gained by slight flexion of the knee.

A triangular graft of full thickness of iliac bone is used to fill in the opening wedge. Chip grafts have not been found satisfactory, because they are prone to become displaced into the medullary cavity and therefore give no stability. On the other hand the full-thickness graft, being bounded by a thin layer of cortical bone on three sides, has the necessary rigidity, and thus gives some fixation to the bones. It has been found to be rapidly and readily reorganized, probably because its center is composed of cancellous bone. The size of the graft may be predetermined from the tracings previously made. It is easily cut to the required size and shape. In some instances, where complete correction cannot be obtained at the time of operation, grafts may be smaller than originally planned.

If correction can be easily obtained, a long screw is passed from the ledge of the distal fragment across the osteotomy, transfixing the graft into the medial cortex of the proximal femoral fragment. If full correction cannot be obtained at the time of operation, a screw pin may be passed across the osteotomy and graft with its end protruding through the skin. In such cases, two additional, but heavier, screw pins are used. One is placed obliquely downward and medially through the proximal fragment of the femur, and one obliquely upward and medially through the upper tibia (Fig. 2-F). All three pins are caught and held in a specially devised clamp. The clamps are incorporated in the spica cast. About five weeks after the operation a turnbuckle is applied on the lateral side of the cast and a hinge on the medial side. The cast is then

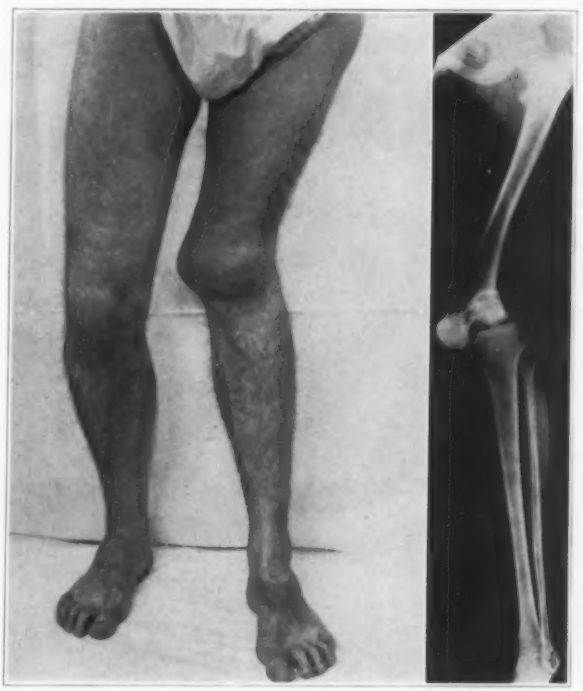

FIG. 2-A FIG. 2-B

Fig. 2-A: Case 2. H. V. Photograph showing the severe valgus deformity.

Fig. 2-B: Teleoroentgenogram of the bone deformity. Six inches of functional shortening was present.

cut at the level of the site of the osteotomy. The transfixing screw pin is backed out until it disengages the proximal femoral fragment, and wedging is begun and continued slowly until full correction has been obtained, or until symptoms of stretching of the peroneal nerve ensue (Fig. 2-G). The screw will thus hold the graft to the distal fragment, which position is held until union is complete. Following removal of the apparatus, exercises for the knee are started. If compensatory deformity of the tibia is present, it should be corrected by a second osteotomy after the fragments at the site of the femoral osteotomy are firmly united. The oblique tibial osteotomy is performed similarly, and a small triangular graft of iliac bone is inserted into the open wedge on the medial side, and held with a transfixion screw or removable screw pin. Further fixation is obtained by means of a plaster cast (Fig. 2-H).

The following case report will illustrate the application of these principles in the treatment of a case with severe and fully developed valgus deformity.

FIG. 2-C

Photograph after the supracondylar osteotomy. The full correction of the valgus deformity of the femur has produced a bowing of the leg. This is due to the compensatory varus deformity of the upper tibia.

CASE 2. H.V., twenty-four years of age, sustained an injury to the left leg at the age of six years. It was stated that roentgenograms had revealed a small chip fracture at the lower end of the femur. Treatment consisted of a plaster-of-Paris cast which was worn for only a few weeks. Several months later the left leg began to turn outward at the knee, without pain. A corrective brace was prescribed, but the angulation continued to increase until the age of twelve years. From that time the deformity remained stationary. However, as the patient grew taller, the relative shortening of the left leg increased; this leg tired more easily on exertion than the right. On several occasions overexertion caused swelling and pain on motion, which lasted for several days.

Examination showed marked adduction of the upper leg when the patient tried to place the foot on the ground in walking (Fig. 2-A). Roentgenograms revealed a marked valgus deformity of the left knee caused by a lack of downgrowth of the lateral condyle of the femur (Fig. 2-B). The angle of the condyles with the shaft was about 40 degrees. Drawings were made from teleoroentgenograms. Comparative measurements from the tip of the greater trochanter to the lateral epicondyle revealed a shortening of five and two-tenths inches. Comparative measurements from the head of the femur to the medial condyle disclosed a loss of growth of four inches. Tracings of teleoroentgenograms of both legs, measured across the angulation from the head of the femur to the medial malleolus of the tibia, showed a total functional shortening of six inches in the left leg. The tibiae were the same length, although a compensatory varus deformity was present in the upper left tibia. A supracondylar open-wedge osteotomy of the femur was planned from the drawings as a primary operation, this procedure to be followed by a high open-wedge osteotomy of the tibia. From the tracings it was believed that the complete final shortening could be reduced from six to three and three-quarters inches by these two procedures (Fig. 3).

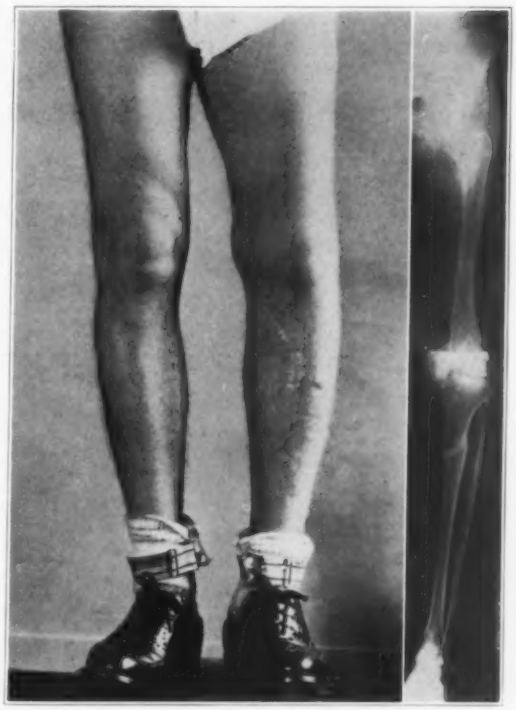

FIG. 2-D FIG. 2-E

Case 2. H. V. Photograph and roentgenogram showing the final result. The patient has 100 degrees of flexion at the knee with good extension. Two inches in length has been gained.

The supracondylar osteotomy with iliac graft was performed on September 20, 1939. Full correction could not be obtained at this time, because the peroneal nerve would not permit it. The clamp and screw pins were applied, and the patient was placed in a spica cast (Fig. 2-F). On November 6, six weeks after the operation, the transfixing pin was backed out of the proximal fragment, the cast was split, hinges were applied, and wedging was begun by means of a turnbuckle. Correction was increased until December 4, when symptoms of stretching of the peroneal nerve manifested themselves (Fig. 2-G). One month later, January 5, 1940, the cast was removed and bony union was found to be complete (Fig. 2-C). Motion at the knee was begun and 40 degrees of flexion was obtained.

On May 1, 1940, the patient reentered the hospital, at which time an osteotomy of the tibia was performed. The line of osteotomy was oblique and ran upward from the medial to the lateral side to about one inch below the tibial tubercle. The osteotomy was planned so that the axis of rotation would pass through the proximal tibiofibular articulation. The iliac graft was placed in the open wedge on the medial side, and the corrected position was maintained by an oblique screw pin. Fixation was secured by means of a plaster-of-Paris cast, which was removed in August 1940 (Fig. 2-H).

The patient was last seen on April 24, 1941. The knee could be flexed to 90 degrees, and fully extended with good power. There was very slight lateral instability of the

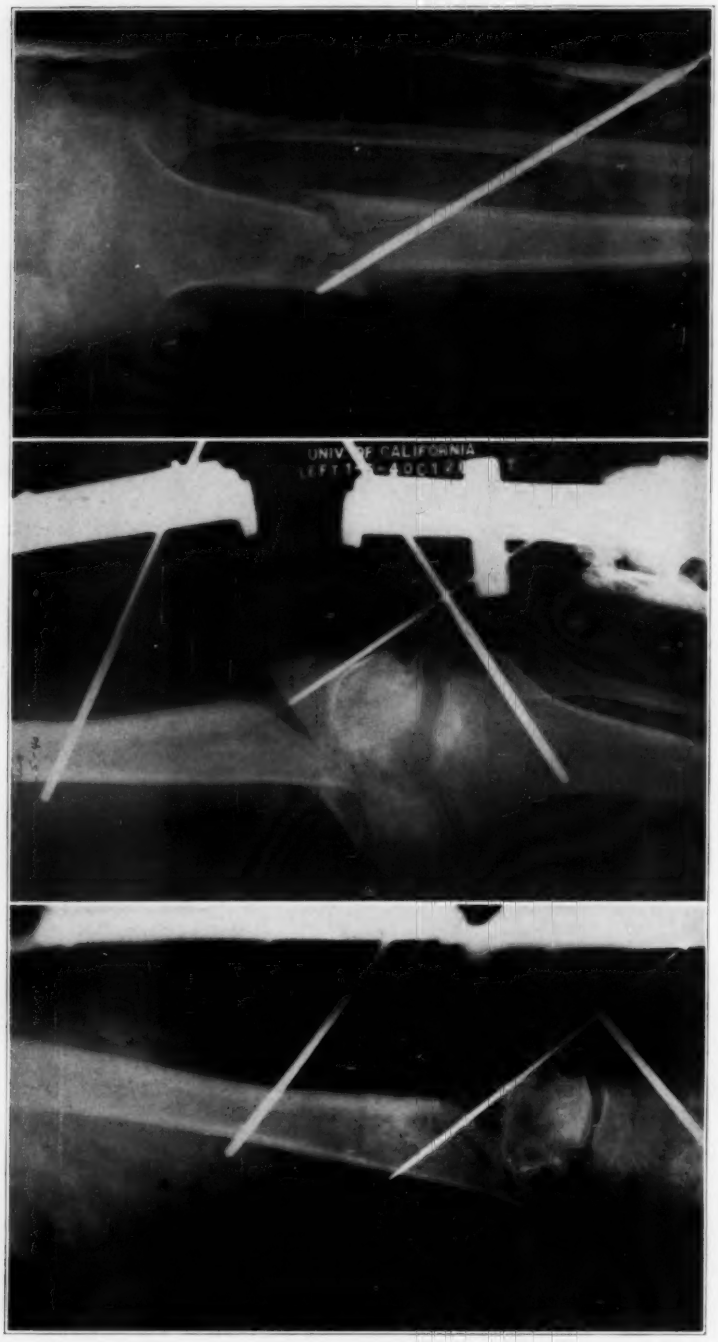

FIG. 2-F FIG. 2-G FIG. 2-H

Case 2. H. V. Roentgenograms showing details of the corrective procedure.
Fig. 2-F: Immediately after supracondylar osteotomy and insertion of the iliac graft. The transfixion screw pin is in place.
Fig. 2-G: After partial withdrawal of the transfixion pin and after wedging.
Fig. 2-H: After osteotomy of the tibia, and insertion of the iliac graft and transfixion screw pin.

PLAN FOR OPERATIVE CORRECTION OF FULLY DEVELOPED GENU VALGUM DEFORMITY AND END RESULT ATTAINED.

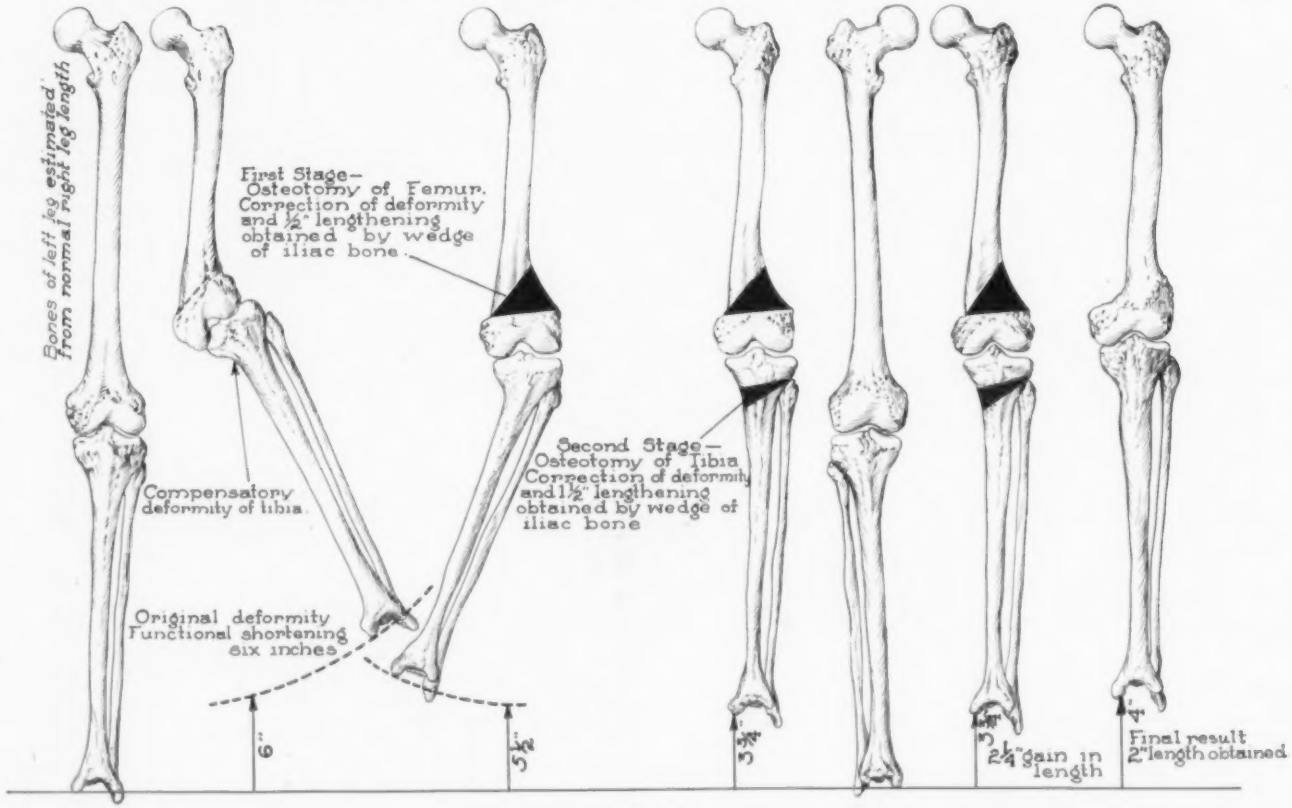

FIG. 3

Drawings from teleoroentgenograms to show the plan of operative correction followed in Case 2 and the comparison of the final result with the preconceived plan.

knee, which caused no disability. The cosmetic result was good (Fig. 2-D). Teleoroentgenograms revealed very close correlation between the plan of operation (Fig. 3) and the correction actually secured (Fig. 2-E).

By means of two such osteotomies, as much as two inches of functional length may be gained. If an undesirable discrepancy is present after these procedures, the normal femur may be shortened or the involved femur may be lengthened. If it is obvious from the preoperative planning that shortening of the normal femur is desirable, time may be saved by performing this operation during the interval between the two osteotomies.

THE CORRECTION OF DEFORMITY IN THE GROWING CHILD

When a valgus deformity due to injury is developing in a growing child, continued growth from the medial portion of the affected cartilage plate and growth from the corresponding plate of the normal femur should be considered when surgical treatment is planned. It is the authors' opinion that the medial portion of the cartilage plate should be permitted to grow, and that the open-wedge osteotomy should be performed during the period of growth. Recurrence of the deformity will, of course, take place, and on first thought it would seem logical to delay surgical correction until the end of the growing period. However, if correction is delayed, the deformity is likely to become so severe and the relative shortness of the soft structures of the lateral aspect of the knee so marked that full correction of the deformity by the open-wedge method is much more difficult. For this reason, if possible, the medial condyle should never be permitted to overgrow the lateral condyle by more than three-quarters of an inch. In this way the shortening of the soft parts and nerves will never be great enough to require strenuous and prolonged postoperative lengthening. Therefore, as often as necessary during the period of growth the lateral condyle should be brought down to the level of the medial condyle, and in some instances, when further growth is anticipated, correction of the deformity may be obtained and the growth of the medial portion of the plate may be utilized to gain increased length. The deformity may recur and the osteotomy may be performed again or even a third time, the final correction being made at the time growth ceases in the medial portion of the plate. By these successive osteotomies from one to two inches of lateral femoral length may be obtained, and the functional shortening thus eliminated. Compensatory deformity of the tibia and strain on the ligaments of the knee will not ensue, because deformity and subsequent abnormal weight-bearing stresses are not allowed to develop to a marked degree. The patient is thereby enabled to enjoy the normal activities of childhood and early adult life, interrupted only by two comparatively short periods.

Fusion of the growing portion of the epiphyseal cartilage plate will also prevent the deformity from progressing, and, if performed at the inception of the difficulty, it will prevent deformity. It is believed that

this procedure is justified only if the growth potentiality is very small, or if the patient promises to be a fairly tall individual who can afford to sacrifice some longitudinal growth.

While the involved leg is being considered, the potential growth of the normal leg must be closely watched. The growth of the normal femur from its head to the medial condyle should never be permitted to exceed the length of the affected femur by more than two inches. If, at the time treatment is begun, the probable final stature of the child minus the expected growth from the injured center will give a satisfactory height, fusion of the epiphyseal cartilage plate of the normal femur should be done. As a result, the final discrepancy in leg length would be slightly over one inch, which may be compensated by a lift on the shoe.

The following case report illustrates the above principles of treatment.

CASE 3. R. J. was first examined at the age of five years and nine months. He had fallen from a three-story building and sustained a fractured skull, a compound comminuted fracture of the middle of the shaft of the left femur, and a small crushing fracture, involving the lateral portion of the epiphyseal cartilage plate and the lateral condyle, with no displacement. He was treated with traction, and an excellent correction of the fracture was obtained. He began to walk shortly thereafter and neither deformity nor shortening was present. Six months later an outward bowing of the left knee developed, and this gradually increased. The deformity was allowed to progress until the medial condyle had grown downward to about one inch below the lateral condyle. At this time the patient was eight years and four months of age. Growth-arrest lines in the normal femur demonstrated that a growth of one and one-half inches had occurred from the distal end. Comparative teleoroentgenograms from the tips of the trochanters to the lateral epicondyles showed one and one-half inches of shortening on the left side. This was equivalent to the growth which should have occurred normally. At this time, a low oblique supracondylar osteotomy of the femur was performed about one inch above the lateral epicondyle. The opening wedge was packed with iliac bone. The iliotibial band and the biceps muscle were lengthened, and the peroneal nerve was freed. The leg was placed in a spica cast. Wedging was begun immediately and continued for several weeks until overcorrection had been obtained. The postoperative course was uneventful, and, in about three and one-half months, he began to walk with the support of a brace.

When the patient was ten years old the deformity began to recur. Ten months later the medial condyle had overgrown the lateral condyle by one-half inch. At this time a supracondylar osteotomy was again suggested, but was rejected by the parents. Therefore, the medial portion of the epiphyseal cartilage plate at the lower end of the left femur and the entire distal epiphysis of the normal side were fused. Comparative teleoroentgenograms at this time revealed that, from the head of the femur to the tip of the medial condyle, the normal femur had exceeded in growth the involved femur by one and one-half inches. Growth-arrest lines showed that the normal femur had grown one and four-tenths inches from the distal epiphyseal cartilage between the ages of eight years and four months and ten years and ten months, and that the total growth of this center from the date of the original injury was two and nine-tenths inches. The downgrowth of the medial condyle of the affected femur was about one-half that of the normal femur. The comparative measurements from the tip of the trochanter to the lateral epicondyle were interesting, because they showed that the involved femur was two and two-tenths inches shorter than the normal one. From this it is seen that the oblique open-wedge osteotomy contributed seven-tenths of an inch to the length of the lateral side of the femur. If the osteotomy had been performed again, another one-half inch in length would no doubt have been gained. At the present time the patient

has a functional shortening of one and one-half inches. The fusion of the normal epiphyseal plate was done at the early age of ten years and ten months, because the predicted final stature of this individual was six feet and two inches, and the calculated growth from this center was three and one-half inches. Therefore, the loss of growth from fusion of the normal eiphysis would give a reduction in final stature to five feet and ten and one-half inches.

The child was last seen at the age of twelve years and nine months, at which time the inequality in the length of the legs had remained constant. The deformity at the

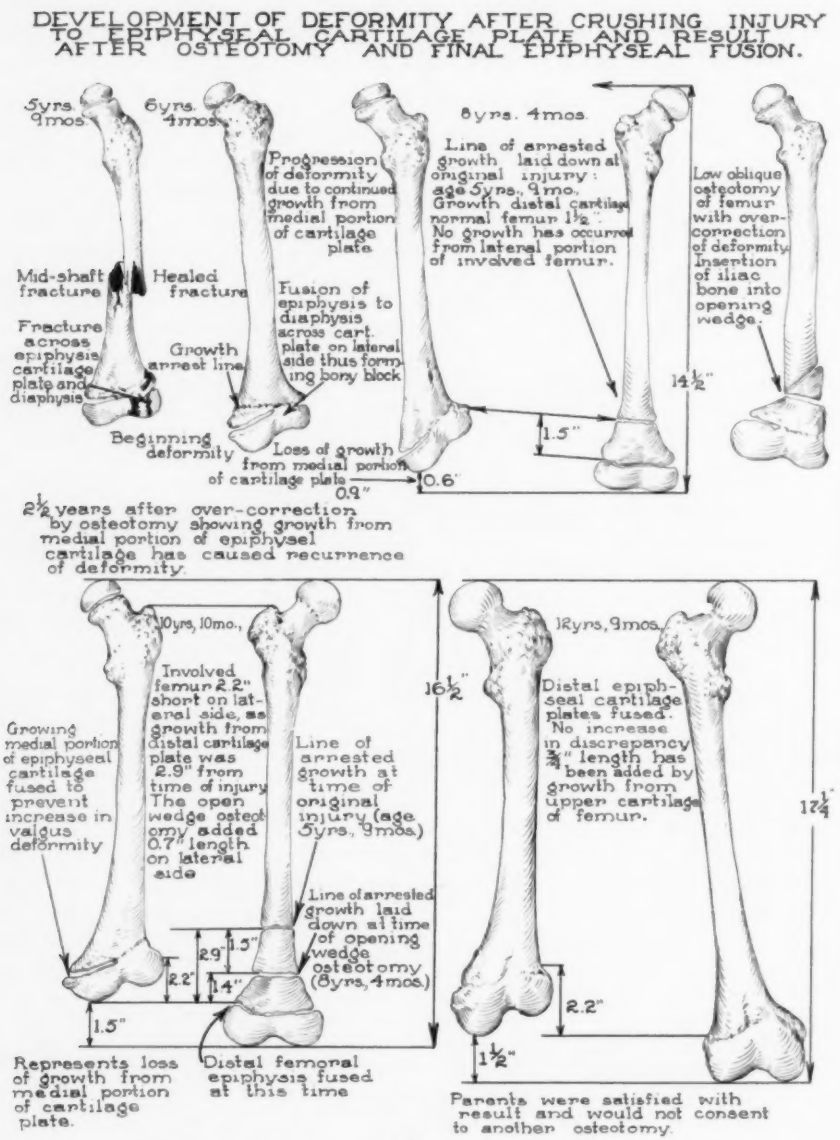
DEVELOPMENT OF DEFORMITY AFTER CRUSHING INJURY TO EPIPHYSEAL CARTILAGE PLATE AND RESULT AFTER OSTEOTOMY AND FINAL EPIPHYSEAL FUSION.
5yrs. 9mos.
6yrs. 4mos.
8yrs. 4mos.
Progression of deformity due to continued growth from medial portion of cartilage plate
Line of arrested growth laid down at original injury: age 5yrs., 9mo. Growth distal cartilage normal femur 1½". No growth has occurred from lateral portion of involved femur.
Low oblique osteotomy of femur with over-correction of deformity. Insertion of iliac bone into opening wedge.
Mid-shaft fracture
Healed fracture
Fusion of epiphysis to diaphysis across cart. plate on lateral side thus forming bony block
Fracture across epiphysis cartilage plate and diaphysis
Growth arrest line
14½"
1.5"
Beginning deformity
Loss of growth from medial portion of cartilage plate
0.9"
0.6"
2½ years after over-correction by osteotomy showing growth from medial portion of epiphyseal cartilage has caused recurrence of deformity.
10yrs, 10mo.,
16½"
Involved femur 2.2" short on lateral side, as growth from distal cartilage plate was 2.9" from time of injury. The open wedge osteotomy added 0.7" length on lateral side
Growing medial portion of epiphyseal cartilage fused to prevent increase in valgus deformity
Line of arrested growth at time of original injury (age 5yrs., 9mos.)
Line of arrested growth laid down at time of opening wedge osteotomy (8yrs, 4mos.)
2.9"
1.5"
2.2"
1.4"
1.5"
Represents loss of growth from medial portion of cartilage plate.
Distal femoral epiphysis fused at this time
12yrs, 9mos.
Distal epiphseal cartilage plates fused. No increase in discrepancy ¾" length has been added by growth from upper cartilage of femur.
17¼"
2.2"
1½"
Parents were satisfied with result and would not consent to another osteotomy.

FIG. 4

Case 3. R. J. Drawings from roentgenograms to show the initial injury, the developing deformity, the operative correction, and the end result.

knee had not progressed and was hardly noticeable. Function was normal and there was only a slight degree of laxity of the external lateral ligament. When the patient stood on the good leg, his height was already five feet and five inches (Fig. 4).

A somewhat comparable case was treated in a very different manner.

CASE 4. L. H., at the age of twelve, sustained a fracture of the shaft of the right femur in an automobile accident. Two deep cuts on his right knee were apparently disregarded. A cast was applied and he was discharged after a month's time. However, he returned to the hospital because of displacement of the bone fragments. Four months later weight-bearing was begun. After he had been walking for two months, an increasing valgus deformity of the right knee was noted. At the time of entering the hospital at the age of thirteen years and ten months, a marked valgus deformity was present with almost one inch of shortening on the lateral side of the femur. A closed-wedge osteotomy was performed, and the medial growing side of the plate was fused. The fragments were held by means of a metal staple. Four months later there was solid union and the patient began to walk. The deformity remained stationary and did not recur. The patient was able to carry on a very active life.

He was seen again at the age of seventeen years and eight months, following an injury sustained while pole-vaulting. At this time he had slight lateral mobility. Immobilization in a plaster-of-Paris cast for five weeks relieved the pain; the knee was stable; and a normal range of motion was present. Externally the knee appeared to have a slight posterior angulation of the femoral condyles and a slight anterior angulation of the upper tibia.

Teleoroentgenographic measurements from the trochanters to the lateral epicondyles revealed a comparative shortening of two and six-tenths inches. As the closed-wedge osteotomy did not disturb the length on the lateral side of the femur, this difference must represent the actual growth of the distal epiphyseal cartilage of the normal femur from the time of injury. Measurements from the heads of the femora to the medial condyles revealed a shortening of two and two-tenths inches. These figures demonstrated that the loss of length of the medial side of the femur was not so great as that on the lateral side, even though some length was sacrificed by the closed-wedge osteotomy. This shortening could have been reduced to less than one inch, if fusion of the distal epiphyseal cartilage of the normal femur had been done at that time. However, as the final height is only sixty-eight inches, this procedure would have reduced it to about sixty-six and five-tenths inches, which is on the short side.

The authors believe that open-wedge osteotomies would have been preferable in this case. At the time of the operation, the medial condyle had overgrown the lateral condyle by about eight-tenths of an inch, and this length was sacrificed by the closed-wedge osteotomy. In addition, if the medial growing portion of the plate had not been fused, it would have grown another inch, as the growth from the distal epiphyseal cartilage plate of the normal femur was about one and seven-tenths inches. Had open-wedge osteotomies been done, from one and one-half to two inches of length would have been gained, and this would have left a shortening of less than one inch instead of the present shortening of over two and one-half inches.

It is felt that the closed-wedge osteotomy, with attendant fusion of the growing portion of the cartilage plate and of the corresponding cartilage plate of the normal femur, should be done only if very little growth expectation remains, or if the expected final stature is predicted to be such that the loss of growth by this procedure will not be too great.

In patients with inception of the deformity from very early childhood, and in whom the open-wedge osteotomy combined with fusion of the epiphyseal cartilage plate of the normal femur would result in too great a decrease in total final stature, a plan for the lengthening of the involved femur should be made. Difficulties will be encountered, however, if the lengthening is not done until after the valgus deformity has been corrected as shown in the following case report.

CASE 5. J. B. When the patient was two years old, the parents noted the development of an outward angulation at the right knee. No definite history of trauma was obtainable, but roentgenograms taken at that time revealed a fusion of the lateral portion of the epiphysis to the diaphysis. At the age of five years a supracondylar osteotomy was performed at a point more than two inches above the condyles, and the leg was bent inward. This gave fair correction of the deformity, which, however, soon recurred. At the age of nine years the deformity had become stationary, but the discrepancy in length had increased. The girl entered the hospital at the age of twelve years. A marked valgus deformity was present, as well as a shortening of the entire leg of over four inches. A femoral lengthening was performed. Lengthening of two inches was obtained, and the valgus deformity was apparently lessened. This decrease in the valgus deformity was produced by a lateral bowing at the site of the lengthening, which converted the femur into an S-shaped curve.

Fusion of the distal epiphyseal cartilage plate of the normal femur was performed at the age of twelve years and nine months. Nine months later she entered the hospital for correction of the remaining valgus deformity of the right knee. There was a question as to whether the procedure should not be divided with correction of the bowing of the mid-femur before the supracondylar osteotomy was performed. It was wished not to submit this patient to two operations, and, since it was thought that the bowing would tend to decrease, the supracondylar osteotomy was decided upon. This was performed at the age of thirteen years and four months. The wedge was packed with chips of iliac bone. These gave no stability and became displaced into the medullary cavity. The osteotomy was held by a transfixing screw pin and two other pins,—one in the femur and one in the tibia. These two pins were caught in a clamp. In four months' time the fragments were solid and motion was begun at the knee. The patient was last seen on May 15, 1941. When she stood on the normal leg, her height was sixty-two inches. A lift of two and one-half inches was required to balance the pelvis. A marked bowing of the mid-femur was present, although the general alignment of the lower leg with the body was good. The plane of motion at the knee joint was normal, and the range of motion was from 180 to 90 degrees. The power of extension of the knee was poor, due in part to the abnormal muscle pull across the bow of the femur.

The correction of the lateral bow of the femur by osteotomy is now being considered. This will probably necessitate a further correction of the valgus deformity of the knee.

SUMMARY AND CONCLUSIONS

1. Valgus deformity of the knee, following injury in childhood, is commonly the result of premature closure of the lateral portion of the epiphyseal cartilage plate of the distal end of the femur. The type of injury producing this premature closure is a crushing of the cartilage plate, and is most commonly received from a fall from a considerable height.

2. Severe angulation of the knee occurs if the injury takes place in a young child. Marked loss of function is caused by the degree of angulation and shortening.

3. Supracondylar osteotomy of the open-wedge type, with lengthening of the soft structures on the lateral side of the knee, gives excellent anatomical reconstruction and added length to the femur.

4. If compensatory deformity of the tibia is present, this should also be corrected by open-wedge osteotomy, which gives additional length to the leg.

5. The osteotomies should be carefully outlined on tracings of the teleoroentgenograms.

6. A triangular, full-thickness wedge of iliac bone has been found to be the most advantageous type of bone graft to place in the open wedge.

7. In the growing child with developing deformity, open-wedge osteotomy should be performed before the medial condyle has overgrown the lateral condyle by more than one inch. The operation should be repeated as often as necessary during the period of growth. In this manner, added length is obtained with each osteotomy; the deformity is never severe; and correction is easier to obtain.

8. Arrest of the corresponding epiphyseal cartilage plate of the normal femur should be performed before the normal femur has overgrown the involved femur by more than two inches, providing the expected final height is satisfactory with this loss of growth.

9. If necessary to give a more desirable final height, femoral lengthening may be performed. It should not be done until the valgus deformity has been fully corrected.

1. Gill, G. G., and Abbott, L. C.: Varus Deformity of Ankle Following Injury to Distal Epiphyseal Cartilage of Tibia in Growing Children. Surg. Gynec. Obstet., LXXII, 659, 1941.

CALCAREOUS TENDINITIS IN THE METACARPO-PHALANGEAL REGION *

BY WILLIAM COOPER, M.D., NEW YORK, N. Y.

From the Hospital for the Ruptured and Crippled, New York

Amorphous calcium deposits in the soft tissues about joints has in recent years become a very familiar phenomenon, and has been variously reported as *bursitis calculosa, calcifying bursitis, tendinitis calcificans, peritendinitis calcarea,* but most frequently as simply *bursitis with a deposit.* It has been demonstrated in many body areas, most familiarly in the subdeltoid, trochanteric, and radiohumeral locations. This paper will discuss another type, less familiar perhaps, but possessing characteristics common to the phenomenon as a whole, and, because of its location, presenting interesting differential features.

Growing experience with the general condition of so-called calcareous bursitis, and a review of the reported material, seems to indicate rather convincingly that it is a genuine disease entity, having a typical pathology and symptomatology common to all areas involved.

Pathological studies have been reported of the various areas in which calcification occurs, and the findings have been quite consistent. Practically all seem to indicate that the condition is secondary to a degenerative change in the tendons, or the adjacent ligamentous or capsular structures. The most conspicuous histological feature is the degenerative alteration in the fibrous tissue (Figs. 2-A and 2-B). The degeneration may vary in degree from trivial loss of microscopic detail in the connective tissue, to true necrosis. In such areas, apparently because of deficient blood supply, calcium is deposited in the form of calcium phosphate or of calcium carbonate, or a molecular combination of both. The blood vessels in

FIG. 1-A

Case 1. Photograph at the time of onset showing swelling of the affected hand.

* Presented at the Orthopaedic Section, New York Academy of Medicine, April 18, 1941.

FIG. 1-C

Case 1. Four weeks later the calcification has almost vanished.

FIG. 1-B

Case 1. Roentgenogram reveals a calcific lesion at the fourth metacarpal head.

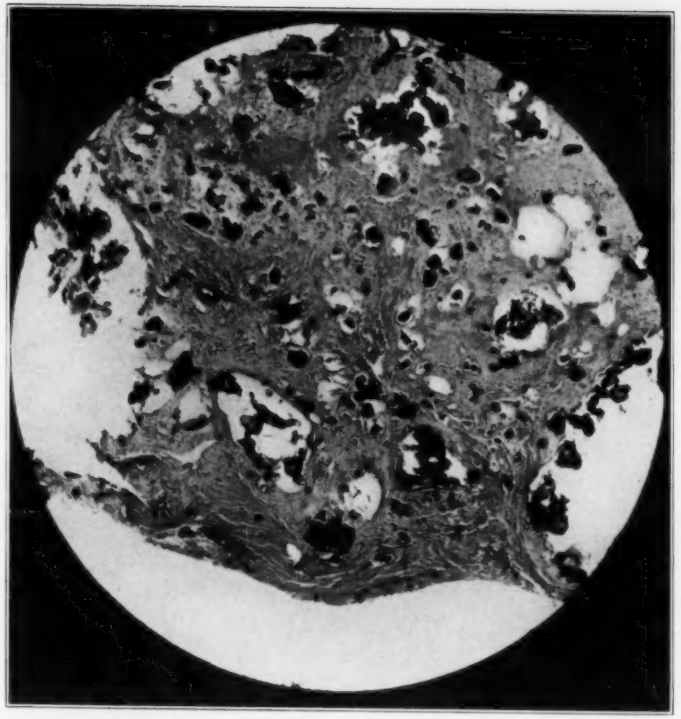

FIG. 2-A

FIG. 2-B

Low-power and high-power views of a section removed from a calcified lesion near the third metacarpal head. Other areas of this section showed approximately normal fibrous structure, but this field shows extensive degenerative alteration. Most conspicuous are the degenerated nuclei, the loss of fibrillar structure, and the masses of amorphous calcium. In the high-power view, there is an area of fairly normal fibrous structure.

TABLE I

RÉSUMÉ OF EIGHT CASES OF CALCAREOUS TEND

TABLE I

RÉSUMÉ OF EIGHT CASES OF CALCAREOUS TENDINITIS IN THE METACARPOPHALANGEAL REGION

Case No.	Age	Sex	Side	Finger	Onset	Symptoms	Roentgenographic Findings	Laboratory Findings	Treatment	Duration of Symptoms
1	59	Female	Right	Fourth	Very acute in every instance without any previous complaint. No preceding history of acute injury or illness. Onset occurred during the day in all but one case.	Pain, redness, and marked swelling of the hand, local heat, and extreme tenderness. Temperature was normal in every case.	Calcific deposit in the region of the metacarpophalangeal joint, of varying size, shape, and density.	Uric acid under oil 5.4 milligrams (low)	Immobilization in plaster-of-Paris cast or splint to finger tips, for 5 to 7 days. Physical therapy for 1 to 3 weeks.	Acute pain, redness, and swelling subsided in about one week. Slight residual symptoms remained for about 3 weeks.
2	36	Female	Right	Third				Uric acid 3.4 milligrams. Sedimentation rate 30 millimeters *		
3	45	Female	Right	Third				Uric acid 3.8 milligrams Sedimentation rate 26 millimeters *		
4	38	Male	Right	Third						
5	51	Male	Right	Third				Uric acid 4.3 milligrams		
6	60	Female	Right	First				Uric acid 2.5 milligrams		
7	50	Male	Right	Second				Uric acid 3.4 milligrams Sedimentation rate 5 millimeters *		
8	60	Female	Right	Third				Uric acid 3.7 milligrams Sedimentation rate 18 millimeters *		

* By Westergren method.

FIG. 3-A

Case 3. Photograph showing swelling of the hand.

these areas may also show degenerative change, with hypertrophy of the media, and narrowing of the lumen. Foreign-body giant cells occur in some fields, and surrounding the areas of degeneration there may be evidence of inflammation with cellular infiltration. The calcified areas increase in size, and eventually coalesce to form larger masses which lie in cavities in or near the tendon. These larger masses are the shadows which are often seen on roentgenograms, and are usually interpreted as lying in a bursa.

No less characteristic is the *symptomatology* of these lesions. In the acute phase, they present the features of an inflammatory process with local redness, heat, pain, swelling, and tenderness. Associated with it there may be, because of pain, restricted mobility of the neighboring joint, an elevated sedimentation rate, and slight fever in occasional cases. The pathognomonic feature is, of course, the presence in the roentgenogram of a typical calcific deposit. Some cases with a deposit are *chronic*, others *latent*, but ordinarily acute symptoms eventually develop in all. The onset of acute symptoms is usually abrupt.

This concept of a *calcareous tendinitis*, or *peritendinitis*, built up from the findings in a great many cases, provides a general heading under which the familiar entities then may be classified, according to their location. Thus there are again as subgroups, rather than as separate entities, subdeltoid bursitis, trochanteric bursitis, radiohumeral bursitis, and the rest,—more properly termed calcareous tendinitis of the structures affected.

To these, the author would like to add the well-defined features of *calcareous tendinitis in the metacarpophalangeal region*. This report is based on eight cases, occurring during a relatively short period of time, which the author has had the opportunity to study and to treat. For these, the age incidence, and other general features, correspond exactly

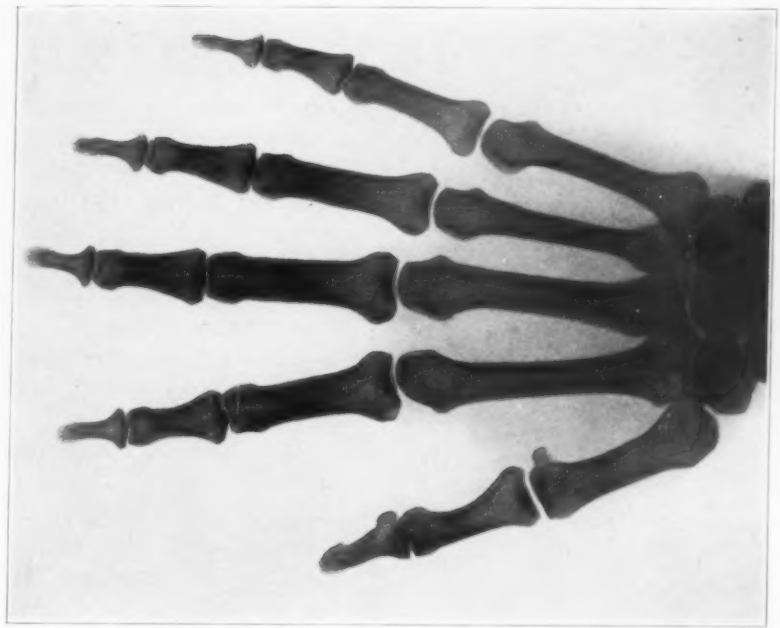

FIG. 3-C

Case 3. Roentgenogram, December 27, 1939, showing small residual calcification.

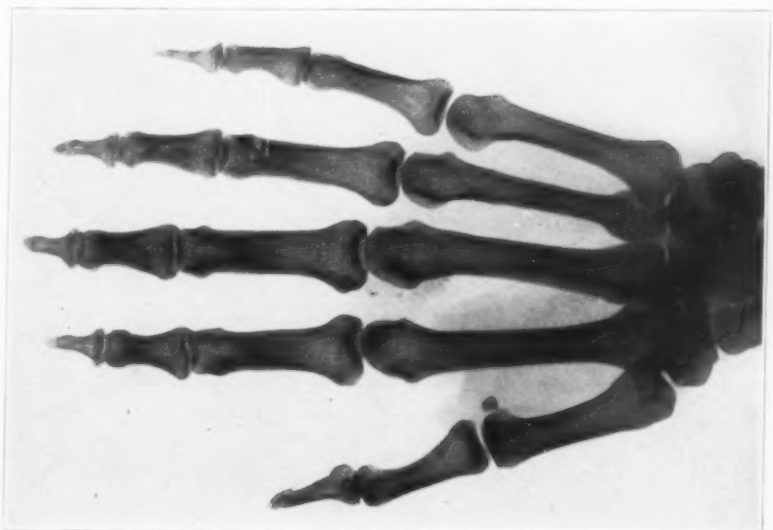

FIG. 3-B

Case 3. Roentgenogram, December 1, 1939, showing calcification at the third metacarpal head.

to those of the condition in other locations. Of particular interest are the modification of the symptoms because of the location, the interesting and characteristic roentgenographic appearance, and the special problem of differential diagnosis. The general features and behavior of these cases are summarized in Table I.

FIG. 4-A

Case 6. Drawing showing the marked swelling of the first interosseous space which the patient in this case presented.

In each of the patients, the *onset* was very acute, and in all but one instance occurred during the day. One patient stated that the onset was associated with a chill which lasted ten minutes. In no case was there any recent trauma or acute illness. Pain, swelling, and tenderness of the hand developed to a remarkable degree in a very short time, varying from a few minutes to a few hours. Most of the patients were seen on the day of onset, and presented severe diffuse swelling (Figs. 1-A, 3-A, and 4-A). There was local heat and redness, and the appearance was strongly suggestive of that seen in acute septic condi-

FIG. 4-B

Case 6. Calcification just proximal to the flexor sesamoid, with evident soft-tissue swelling.

FIG. 4-C

Case 6. At three weeks a very small residual calcification is still evident.

tions of the hands, infections of the palmar space, cellulitis, or acute infectious arthritis.

Roentgenograms in every instance indicated a calcific deposit which corresponded to the area of greatest tenderness. The deposit varied considerably in contour. In some instances it seemed to follow the outlines of the dorsal interossei (Figs. 1-A, 1-B, 1-C, 3-A, 3-B, and 3-C), in others it corresponded to the distribution of the capsule, while in one, it apparently resided in the short flexors of the thumb (Figs. 4-A, 4-B, and 4-C). In examining these patients, a poorly defined nodule could be palpated in the region of the deposit. Motion of the affected finger was markedly painful, especially when the metacarpophalangeal joint was extended with the finger flexed.

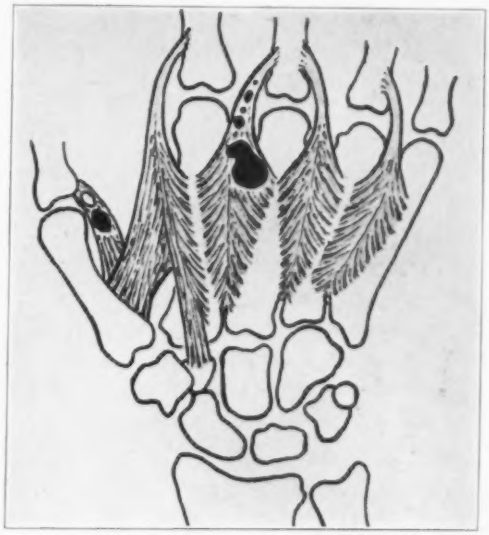

FIG. 5

Diagram showing the dorsal interossei, and the flexor pollicis brevis, illustrating the apparent location of the deposits.

Seven of the eight patients, as indicated in Table I, had blood-chemistry studies which were normal for uric acid (non-fasting). The sedimentation rate in three patients was elevated to thirty, twenty-six, and eighteen. In one it was normal. The temperature was not elevated in any patient.

The clinical resemblance of these cases to uric-acid gout was striking. The dramatic onset, the severe local pain and swelling, were almost typical. The swelling, however, was not the tense bluish type usually seen in gout, and the normal blood chemistries and typical roentgenographic findings served quite definitely to rule out that condition. The term *Kalkgicht*, or calcium gout recurs in the German literature, and would seem to be suitable for this condition, except that that term refers rather to *calcinosis interstitialis circumscripta*.

Treatment of these cases consisted in immobilization in a plaster-of-Paris cast or splint, extending to the finger tips. This gave almost immediate comfort, and was retained for from five to seven days. During this period, the acute pain and swelling subsided in every case. Slight to moderate residual tenderness persisted for about two or three weeks and was treated with physical therapy in the form of diathermy through the clasped hands. In two cases exploration was done with a needle, and a small mass of creamy calcific deposit was aspirated. There was no alteration in the course of symptoms in these two patients. The calcific deposits

appearing on the roentgenograms grew rapidly less prominent, and at the end of a month were very small or absent in every case (Figs. 1-B, 1-C, 3-B, 3-C, 4-B, and 4-C).

COMMENT

The calcium deposits in these and other cases of calcareous tendinitis had undoubtedly been present long before the development of symptoms. The mechanism which precipitates the acute symptoms, as well as the general etiology, remains entirely obscure. All the work which has been done, has shed but little light on these phases of the subject. There exist almost as many hypotheses as writers. Infection and trauma are mentioned most frequently as possibilities. An interesting, and possibly significant etiological suggestion found in this study, is that the symptoms *in every instance occurred in the right hand.* Bearing in mind that the mathematical possibility of this occurring in eight consecutive cases by coincidence, alone, represents one chance in 256, the author is led to believe that the additional trauma of use, to the right hand, in right-handed, middle-aged patients, might be an important factor. By the same token, trauma might well be the important etiological factor in the other locations as well.

SUMMARY

These eight cases of calcification in the metacarpophalangeal region of the hand have characteristic symptoms and findings, and seem to fall into the general class of calcareous tendinitis. There are other sites of calcification in the hand. That which occurs at the pisiform, probably in the tendon of the flexor carpi ulnaris seems to be the most frequent. The essential characteristics of this condition are the same.

AN ANATOMICAL EXPLANATION OF TRAUMATIC LOW-BACK PAIN

BY EDWARD J. HABOUSH, M.D., NEW YORK, N. Y.

Except for a slight diminution in the second, third, and fourth thoracic vertebrae, there is a progressive increase in the width of the bodies extending from the second cervical vertebra to the sacrovertebral angle, thus providing for the progressive increase in the superincumbent weight. Unfortunately, there is not a comparable progressive increase in the leverage action of the posterior neural arches, as the transverse processes of the lumbar vertebrae are situated in front of the articular processes, rather than behind them, as in the thoracic vertebrae. The leverage of the transverse processes of the lumbar vertebrae is, therefore, less.

In the lumbar spine, however, there appears to be an adequate mechanism to provide for the added strain which is placed upon the ligamentous structures of the first, second, third, and fifth intervertebral spaces as the lumbosacral junction, the point of greatest pressure, is approached, but in the fourth interspace the mechanism appears inadequate.

In the first, second, and third lumbar vertebrae, the leverage and the distance between the tips of the transverse processes are progressively increased from the first to the third. The leverage of the first, second, and third is further enhanced by the fact that the transverse processes arise from the junction of the pedicles and laminae, and are more posteriorly placed than in the lower two, where they spring from the junction of the pedicles and posterior parts of the bodies. The transverse processes of the first, second, and third lumbar vertebrae are horizontal, so that the stresses which the intertransverse ligaments receive are evenly distributed, but in the lower two they incline a little upward and their ligaments receive unequal stresses. The fifth interspace—the lumbosacral junction—is greatly reinforced by the powerful iliolumbar ligaments and the more advantageously placed capsules of the lumbosacral joints, but in the fourth interspace the thin, membranous, intertransverse ligaments receive undue and unequal stresses. They are the ones most liable to injury, since the transverse processes of the fourth lumbar vertebra are set farther forward, incline a little upward, and have a shorter leverage because the distance between their tips is greatly diminished to facilitate motion. The weak spot of the lumbar spine is therefore between the fourth and fifth lumbar vertebrae.

Ligamentous and aponeurotic injuries have been noted as one of the many and widely differing causes of low-back pain, and the ligamentous structures of the lumbosacral region have attracted more and more attention as the possible seat of injury, but the exact site, mechanism, extent, and sequelae, are little understood. In the hope of casting some light on these intriguing questions, cadaver specimens of the lumbar spine and pelvis, with their ligaments intact, were subjected to flexion strains.

In order to apply a flexion force in the mid-line and to distribute the pressure evenly throughout the lumbar spine and pelvis, a rather simple apparatus was moored at one end to the first lumbar vertebra and at the other to the symphysis pubis. The device was a screw-and-nut arrangement (Fig. 1) which permitted the pressure to be adequately applied in a continuous, slow, and steady manner, so that the consequent events, in response to a flexion force, would occur at a rate slow enough to be observed.

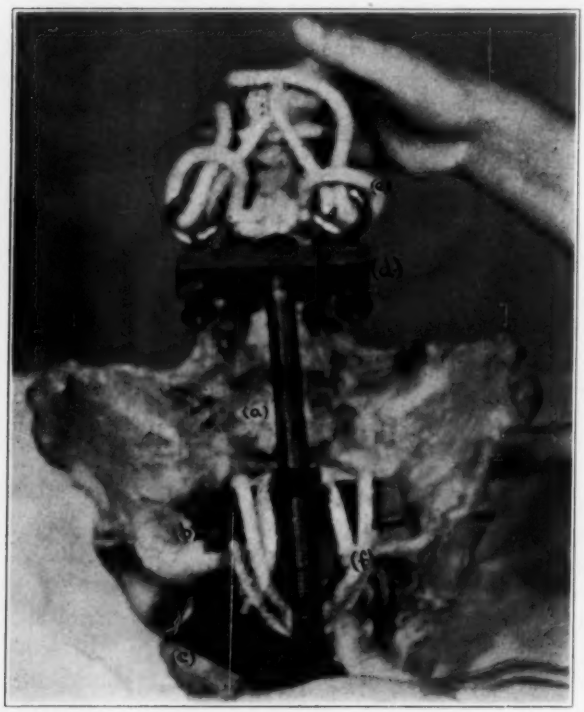

FIG. 1

Anterior view of the lumbar spine and pelvis with ligaments intact, and the apparatus, used to apply flexion force, attached.
(*a*) = Screw.
(*b*) = Nut with welded flange and rope (*f*) used to anchor the nut to the symphysis pubis.
(*c*) = Handle welded to the screw to apply force.
(*d*) = Flat piece of steel with a hole in it, so that the screw could be turned freely.
(*e*) = Rope and knot used for mooring the apparatus to the first lumbar vertebra.

In cadavera, as the lumbar spine is flexed, motion initiated in the lumbosacral junction is limited by the powerful iliolumbar ligaments, and is promptly followed by motion in the fourth interspace,—the apex of the lumbar curve and the seat of greatest motion. Motion continues in the fourth interspace until it is checked, when a smaller amount of motion takes place between the third and fourth lumbar vertebrae. The smallest amount of motion occurs in the first and second interspaces.

When the limit of flexion of the lumbar spine is reached, the very strong supraspinal ligament and lumbar fascia act as a check, produce rotation and lateral deviation of the lumbar spine, and cause the tension to be transferred to the iliolumbar ligament, quadratus lumborum fascia, and intertransverse ligaments on the convex side of the lumbar spine. The explanation for this mechanism may be that, in flexion of the lumbar spine, the upward tilt of the spinous processes imparts a rotary and lateral component to the tense supraspinal ligament and lumbar fascia. Other factors to be considered are tropism, and inequality in the

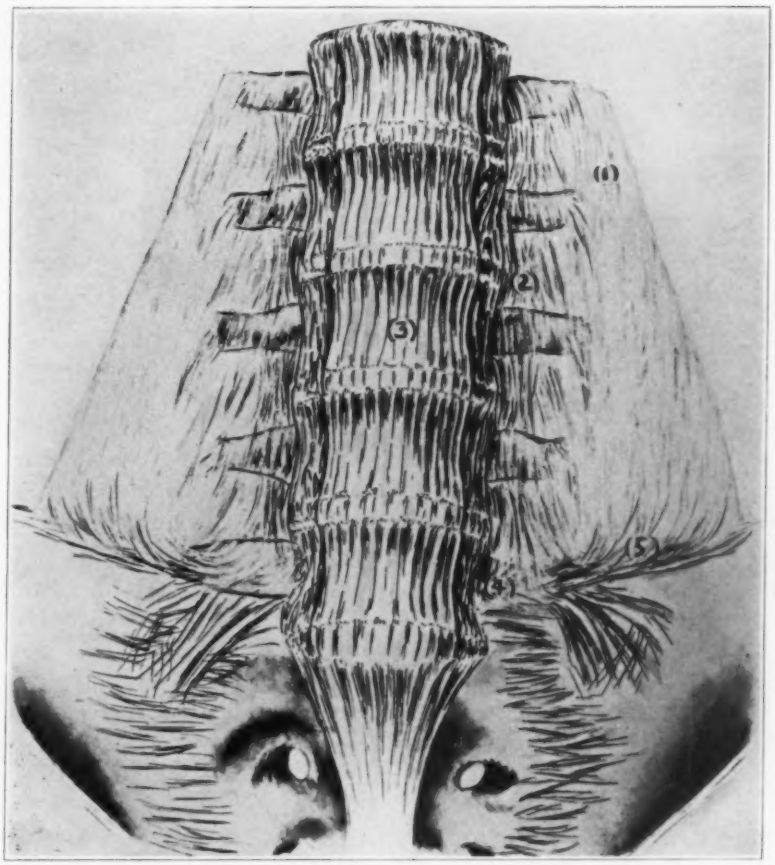

FIG. 2

Anterior view of the lumbar spine and pelvis. The lumbar spine is erect.
(*1*) = Quadratus lumborum fascia.
(*2*) = Intertransverse ligament.
(*3*) = Anterior longitudinal ligament.
(*4*) = Transverse process of the fifth lumbar vertebra.
(*5*) = Iliolumbar ligament.

strength of the ligamentous structures. Also, it is to be remembered, that from a practical standpoint it is almost impossible to apply a flexion force exactly in the mid-line of the spine (Figs. 2 and 3).

However, if forced flexion is now continued, in some specimens the first structures to rupture are the intertransverse ligament and quadratus lumborum fascia between the fourth and fifth lumbar vertebrae on the side of the convexity (Fig. 4-A), since the thin, membranous, intertransverse ligament—the weakest of the ligaments joining the neural arches—and the quadratus lumborum fascia are, at this level, set farther forward, have a shorter leverage, and receive undue and unequal stresses. The iliolumbar ligament is unaffected, even though the tension upon it is greater, because it is very powerful, and is reinforced by the more advantageously placed capsule of the lumbosacral articulation.

Following a rupture of the quadratus lumborum fascia and inter-

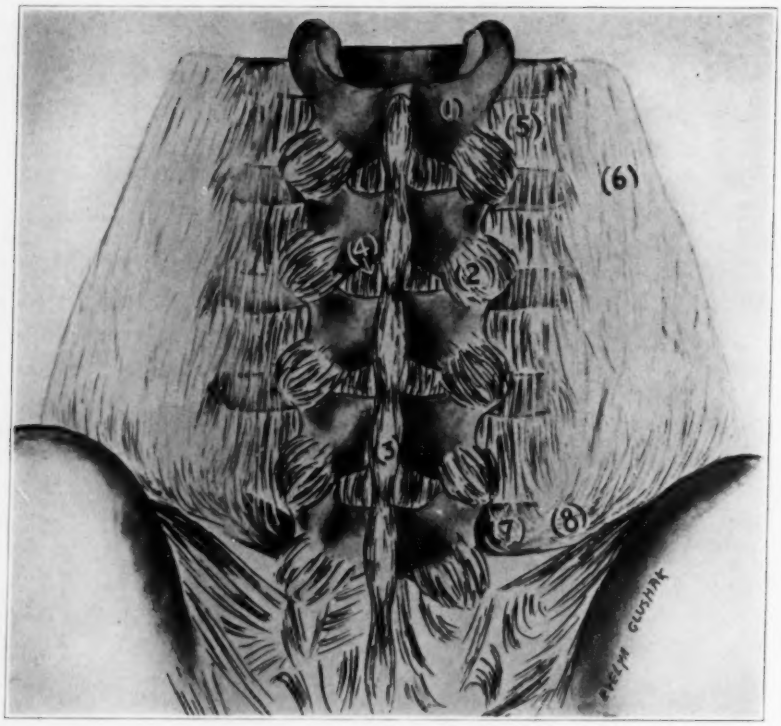

FIG. 3

Posterior view of the lumbar spine and pelvis.

(*1*) = Lamina of vertebra.
(*2*) = Articular capsule.
(*3*) = Supraspinous ligament.
(*4*) = Ligamentum flavum.
(*5*) = Intertransverse ligament.
(*6*) = Quadratus lumborum fascia.
(*7*) = Transverse process of the fifth lumbar vertebra.
(*8*) = Iliolumbar ligament.

transverse ligament, tension is placed on the articular capsule and annulus fibrosus of the same side, and further continued forced flexion causes a tear of a definite pattern to extend through the adjoining ligamentous structures,—just as muslin rents. The tear extends through the lateral-most fibers of the anterior and posterior longitudinal ligaments, the articular capsule, the ligamentum flavum, and the interspinal ligament, and there is a separation of the neural arch on the injured side, with an involvement of the annulus fibrosus, intervertebral disc, and the nucleus pulposus (Fig. 4-B).

On further flexion, the supraspinal ligament is the last structure to rupture, and its rupture is promptly followed by an extension of the tear in a reverse order through the same structures on the opposite side (Fig. 4-C).

These findings may well explain the unilateral involvement of the sciatic nerve roots in cases of low-back pain due to trauma, and the relatively greater frequency of disc lesions at the level of the fourth interspace.

Although ligamentous and aponeurotic injuries occur most frequently

at the level of the fourth interspace, they may occur at other levels, because disc lesions are known to occur at other levels. Hypertrophy of the ligamentum flavum also may be explained on the basis of these findings.

In one cadaver specimen there was a partial ankylosis between the fourth and fifth lumbar vertebrae. The lumbar spine was practically straight when viewed laterally, and the apex of the lumbar curve and the seat of greatest motion were at the lumbosacral junction. In this specimen separation took place at the lumbosacral junction, and a rupture of the quadratus lumborum fascia, with a fracture of the tip of the transverse process of the fifth lumbar vertebra, was first to occur (Fig. 5-A). The small bone fragment, the tip of the transverse process, remained attached to the pelvis by the iliolumbar ligament which remained intact. On further flexion, the tear followed the same pattern as in the normal specimens (Fig. 5-B). When the tear reached the opposite side, it involved the quadratus lumborum fascia, and a fracture of the tip of the remaining transverse process occurred. This also remained attached to the pelvis by the intact iliolumbar ligament (Fig. 5-C). These findings seem to indicate that an involvement of the lumbosacral joint is unlikely, unless a fracture of a transverse process of the fifth lumbar vertebra has first occurred.

Most of the specimens used were of individuals past fifty years of age in whom there was very little or no motion in the sacro-iliac joints. For this reason the specimen of a female, twenty-four years old, with motion in the sacro-iliac joints was tested. The sacro-iliac joints were not affected in any way and separation took place at the lumbosacral junction. On one side a rupture of the quadratus lumborum fascia and a fracture of the tip of the transverse process of the fifth lumbar vertebra occurred. On the other side of the fifth lumbar vertebra, the transverse process did not fracture, nor did the iliolumbar ligament rupture. Separation occurred between the tip of the transverse process and its cartilaginous covering. In this specimen the supraspinal ligament did not rupture at the lumbosacral junction, because a good portion of the lumbar fascia was left attached to the lumbar spinous processes. The supraspinal ligament separated from the sacral spines and ruptured at the sacro-coccygeal junction, because in the sacral region the lumbar fascia was trimmed away from the sacral spinous processes. This may be illustrative of certain cases of unexplained coccygodynia.

In one specimen the intervertebral fibrocartilage, normally adherent to the adjacent vertebral bodies, separated from both the upper and under surfaces, and the disc herniated into the spinal canal. In other specimens herniation of the disc failed to occur, because the disc remained attached to either the upper or under surface, or to both surfaces where separation occurred through the substance of the disc. This may well explain why in so many low-back injuries there are relatively few cases of actual herniation of a disc.

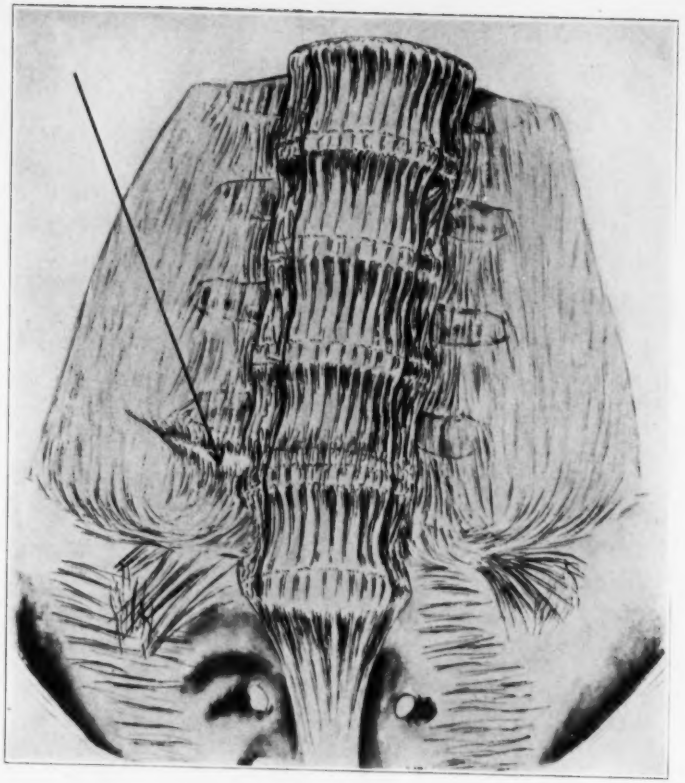

FIG. 4-A

Anterior view of the lumbar spine and pelvis, showing a tear of the quadratus lumborum fascia and intertransverse ligament between the fourth and fifth lumbar vertebrae on the right, or convex, side. Note the left lateral deviation and the rotation of the lumbar spine.

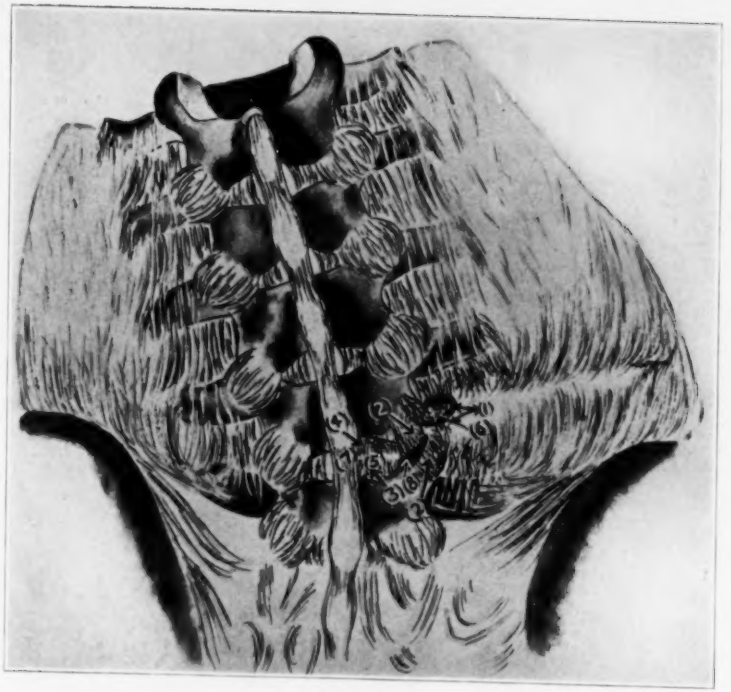

FIG. 4-B

Posterior view of the specimen as seen in Fig. 4-A, showing the lumbar spine and pelvis on further flexion, and the extension of the tear on the right side through the adjoining ligamentous structures to the supraspinal ligament. Note the increase in rotation and shift of the lumbar spine to the left as compared with that in Fig. 4-A.

(*1*) = Lateral fibers of anterior longitudinal ligament.
(*2*) = Articular capsule.
(*3*) = Ligamentum flavum.
(*4*) = Interspinal ligament.
(*5*) = Separation of the neural arches with involvement of (*6*) the annulus fibrosus, and (not shown in this illustration) the posterior longitudinal ligament, intervertebral disc, and nucleus pulposus.
(*7*) = Supraspinal ligament still intact.
(*8*) = Superior articular facet of the fifth lumbar vertebra.

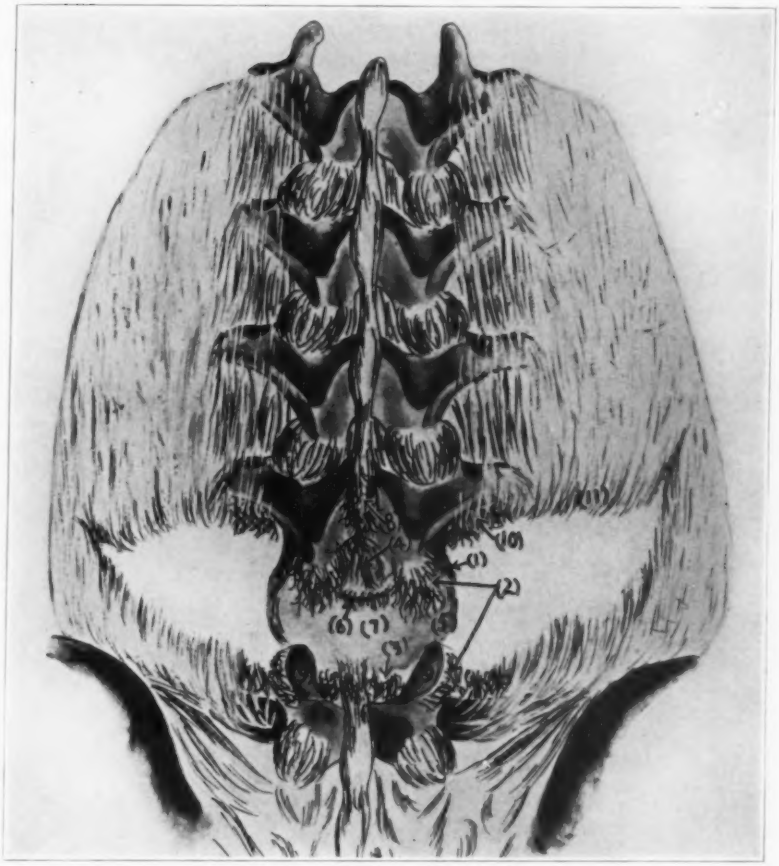

FIG. 4-C

Same specimen as seen in Figs. 4-A and 4-B, but showing extension of the tear on continued flexion. The rupture of the supraspinal ligament is the last to occur, and this is promptly followed by an extension of the tear in a reverse order through the same structures on the opposite side, after which the spine returns to the mid-position.

(*1*) = Lateral fibers of anterior longitudinal ligament.
(*2*) = Articular capsule.
(*3*) = Ligamentum flavum.
(*4*) = Interspinal ligament.
(*5*) = Annulus fibrosus.
(*6*) = Posterior longitudinal ligament.
(*7*) = Nucleus pulposus and intervertebral disc.
(*8*) = Supraspinal ligament.
(*9*) = Superior articular facet.
(*10*) = Intertransverse ligament.
(*11*) = Quadratus lumborum fascia.

It is reasonable to assume that the findings presented may take place in simple flexion injuries in actual life, and during such simple acts as bending down, sneezing, etc., but in a large number of cases the patient is seized with a sudden sharp pain in straightening his back from the flexed position during an act of lifting. It may seem a bit difficult at first to see the relationship between this last group of cases and the findings in cadaver specimens following a flexion force. However, when it is considered that during an act of lifting, there is actually a tug of war between the

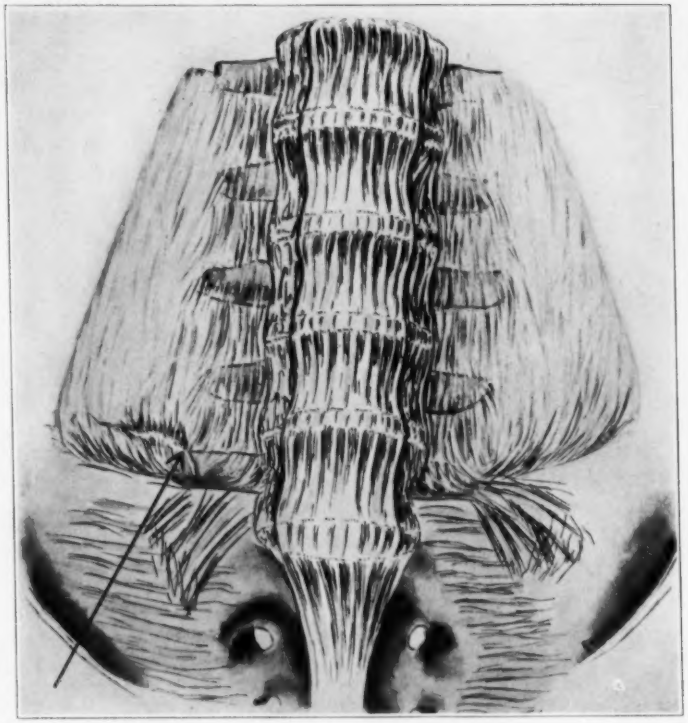

FIG. 5-A

Anterior view of a specimen in which a rupture of the quadratus lumborum fascia and a fracture of the tip of the transverse process of the fifth lumbar vertebra on the right, or convex side, anteriorly were first to occur on forced flexion. Note the rotation and lateral deviation of the lumbar spine to the left as in Fig. 4-A.

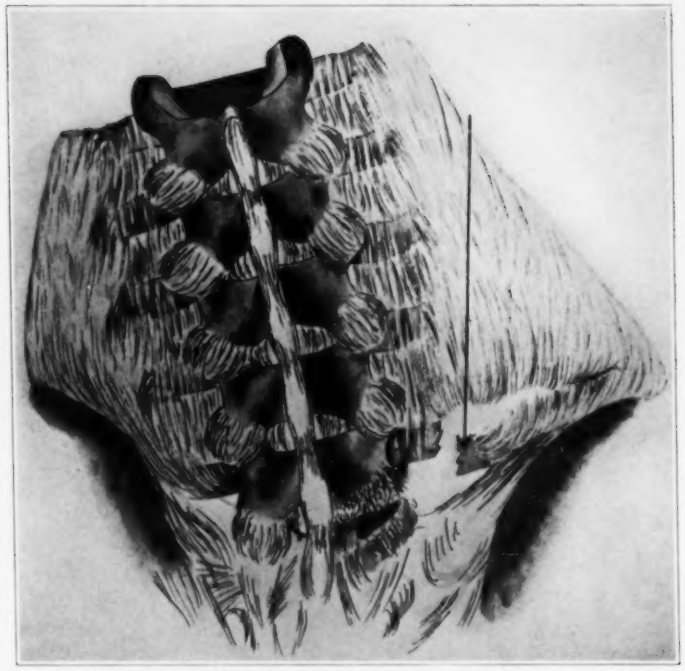

FIG. 5-B

Same specimen as seen in Fig. 5-A, showing involvement of the right side, viewed posteriorly with extension of the tear through the adjoining ligamentous structures of the fifth interspace to the supraspinal ligament, just as occurred in the fourth interspace. Note the increased rotation and lateral deviation of the lumbar spine on further forced flexion. The arrow shows the fractured tip of the transverse process of the fifth lumbar vertebra attached to the iliolumbar ligament which is still intact.

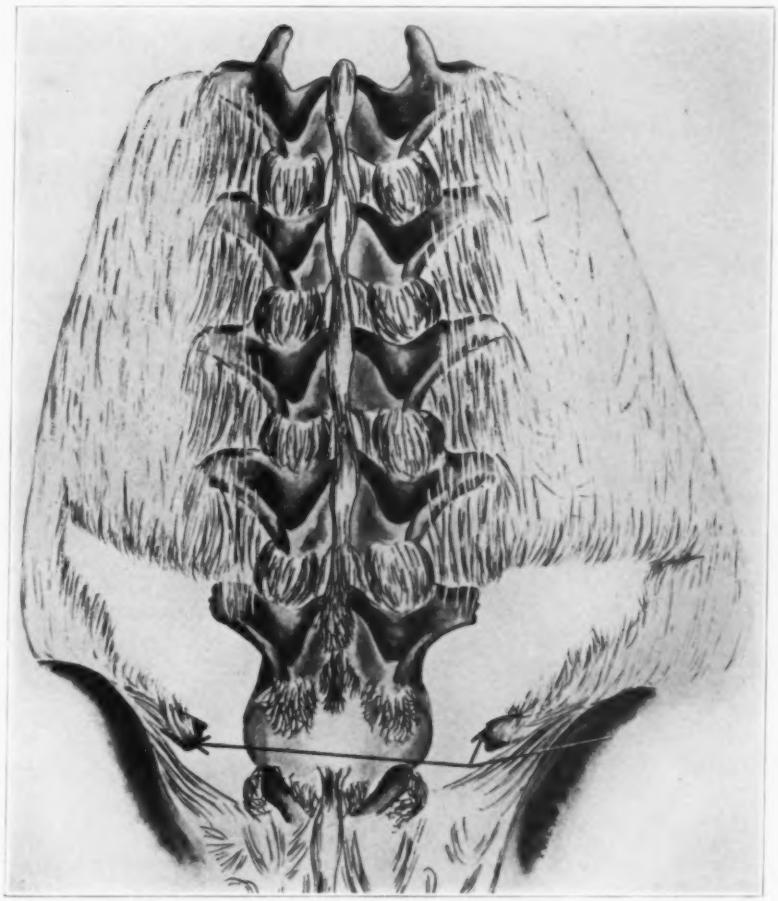

FIG. 5-C

Same specimen as seen in Figs. 5-A and 5-B, also viewed posteriorly, but showing the extension of the tear on continued forced flexion. The rupture of the supraspinal ligament is the last to occur, and is promptly followed by an extension of the tear in a reverse manner through the same structures on the opposite side, after which the spine returns to the mid-position. The arrows show that both fractured tips of the transverse processes of the fifth lumbar vertebra are still attached to the pelvis by the iliolumbar ligaments which did not rupture.

large and powerful spinal muscles on one hand, and the comparatively greater and more powerful combined muscle mass of the hip extensors and hamstrings on the other, it is realized that the lower lumbar spine and lumbosacral junction are in between and share the brunt of the burden. A load that is too great for the large and powerful spinal muscle mass acts to fix the trunk, while the comparatively greater and more powerful combined muscle mass of the hip extensors and hamstrings may extend the pelvis at the hip joints, result in flexion of the pelvis on the trunk, and cause damage to the structures of the lower lumbar spine.

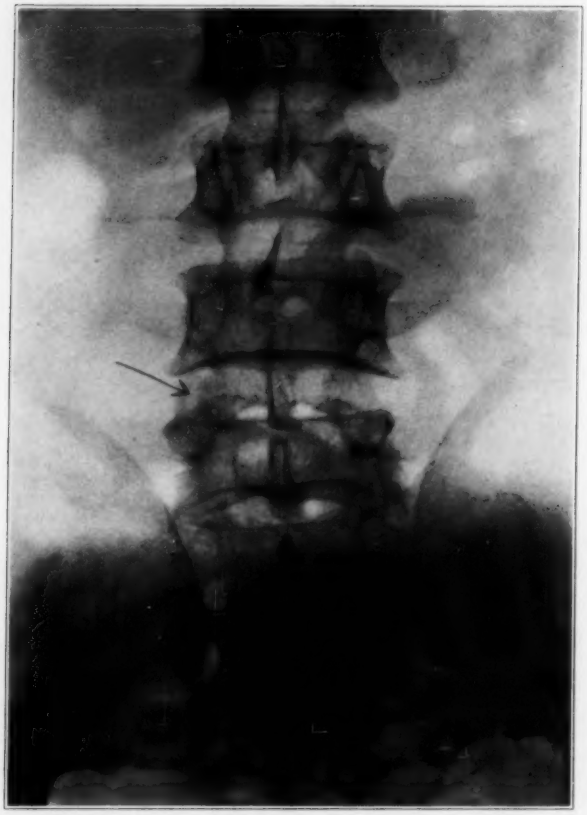

FIG. 6-A

B. A. Anteroposterior view of a spine with abnormal separation of the articular facet between the fourth and fifth lumbar vertebrae on the right side. The spine is tilted somewhat to the left.

Therefore, low-back pain with sciatic radiation, following either a flexion strain or an act of lifting, may be due either to a unilateral rupture of the intertransverse ligament and quadratus lumborum fascia at the level of the fourth intervertebral space, or to a rupture of the quadratus lumborum fascia and a fracture of the transverse process of the fifth lumbar vertebra. The tear may or may not extend through the adjoining ligamentous structures and intervertebral fibrocartilage, and may or may not produce herniation of the disc. Herniation is perhaps dependent upon complete separation of the intervertebral fibrocartilage from both the upper and under surfaces of the adjoining vertebral bodies. Hemorrhage in either of these lesions in the region of the fourth or the fifth lumbar nerve root may well explain the sciatic syndrome.

A fracture of a transverse process of the fifth lumbar vertebra, although known to occur during a flexion strain or an act of lifting, is rather infrequently encountered clinically, since in actual life, the lumbosacral junction, reinforced by the numerous tendinous origins of the spinal muscles, in all likelihood does not represent the site of injury, which is most probably at the level of the fourth lumbar interspace. The greater incidence of fracture of the transverse process of the fifth lumbar vertebra in cadavera is probably due to the fact that in the specimens tested the muscle origins had been dissected away.

In addition to the routine anteroposterior and lateral views, right lateral bending, left lateral bending, and a lateral view of the spine in acute flexion should be taken. The routine anteroposterior view may show a

sciatic scoliosis and the possible level of the lesion, and the roentgenograms of lateral bending may demonstrate an abnormal unilateral separation of the facets of one articulation between the fourth and fifth lumbar vertebrae. If the anteroposterior view presents a fracture of the tip of the transverse processes of the fifth lumbar vertebra, then an involvement of the lumbosacral joint is to be expected on condition that the roentgenograms on lateral bending, show an abnormal separation of the fractured tip of the transverse process and the corresponding lumbosacral joint. In the routine lateral view there is seen usually a loss of the normal lumbar curve at the level of the lesion, but, in the lateral view taken with the spine in acute flexion, there may be an abnormal widening of the involved intervertebral space with an abnormal anterior angulation of the vertebral bodies, and an abnormal separation of the corresponding articulation.

FIG. 6-B

B. A. Postero-anterior view showing left lateral bending with abnormal widening of the fourth interspace on the right side (triple arrows). Note also the partial subluxation of the fourth lumbar vertebra (single arrow).

In a number of cases of traumatic low-back pain with roentgenographic evidence of tropism of the transverse processes of the fourth lumbar vertebra, it was observed that the smaller transverse process was usually associated with the involved side. This is readily appreciable from the standpoint of physiological anatomy, and may speak for tropism as an etiological factor in cases of traumatic low-back pain.

Roentgenograms (Figs. 6-A and 6-B) believed to represent a rupture of the quadratus lumborum fascia and the intertransverse ligament on the right side of the fourth interspace with an abnormal separation of the

articulation are presented purely as illustrations in a preliminary report, and not as case reports such as the author hopes to present in a comprehensive clinical study in a future publication.

The author wishes to express his appreciation to Leo Mayer, M.D., Henry Milch, M.D., and M. M. Pomeranz, M.D., of the Hospital for Joint Diseases, and to Fuad Shatara, M.D., of the Cumberland Hospital, for their many helpful suggestions and kind cooperation in conducting this study.

TUBERCULOSIS OF THE HIP

A Review of Seventy-Six Patients with Proved Tuberculous Arthritis of Seventy-Seven Hips Treated by Arthrodesis

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Seventy-six patients, who had proved tuberculous arthritis in seventy-seven hips, had an arthrodesis of the hip performed as part of their treatment at the University Hospital between 1925 and 1935. To be included in this study each case had to fulfill the following requirements: (1) A diagnosis of tuberculosis of the hip had been substantiated by pathological or bacteriological methods, and (2) an arthrodesis of the hip had been performed.

The purpose of this paper is to present a review of these seventy-six cases, and to evaluate the importance of various factors in determining (1) the optimum time for arthrodesis, and (2) the final result. Particular emphasis is placed upon the influence of the age of the patient, the duration of preoperative care, sinuses, cold abscesses, roentgenographic changes, and tuberculosis in other organs.

HISTORY AND EXAMINATION

The ages of the patients when first examined are presented in Table I. A review of the histories revealed that the duration of symptoms increased in direct proportion to the age of the patients, that the illness was insidious in onset and was characterized by a slowly progressive course in the vast majority, and that tuberculosis in the family was the probable source of the primary focus in 37 per cent.

The interesting clinical findings can be summarized briefly. Eighty-six per cent. of the patients had a flexion deformity of some type (flexion 38 per cent.; flexion adduction 30 per cent.; and flexion abduction 18 per cent.). There was no shortening of the affected extremity in 45 per cent., one inch of shortening or less in 36 per cent., more than one inch of shortening in 17 per cent. (the maximum was three inches), and lengthening in 2 per cent. Fifty patients were given tuberculin skin tests. Forty-seven, or 94 per cent., of these reacted positively, and three had a negative reaction. This test was positive in all patients under the age of twelve years.

ROENTGENOGRAPHIC FINDINGS

The roentgenograms of sixty-seven patients on admission were available for study at the time of this report. The roentgenogram of the hip

was negative in only one instance. In four cases (6 per cent.) the roentgenographic findings consisted of loss of joint space and osteoporosis. All of the remaining patients (93 per cent.) presented some degree of destruction. These destructive changes were classed as mild in 33 per cent., moderate in 27 per cent., and marked in 33 per cent. The destruction was sufficiently severe in 27 per cent. of the sixty-seven patients to produce the so-called "wandering acetabulum". Intrapelvic protrusion of the acetabular floor was present in 6 per cent. A pathological dislocation was found in 6 per cent.

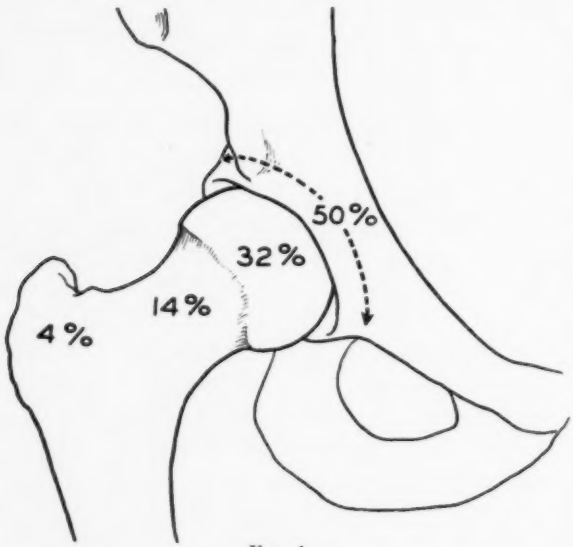

FIG. 1

Region of maximum destruction in twenty-eight patients with tuberculosis of the hip, as seen in the roentgenogram on admission. This area may indicate the site of the primary tuberculous focus.

In 42 per cent., the destructive change was more marked in one particular area of the hip. It is of interest to record this area, since this may indicate the site of the primary tuberculous focus. Figure 1 indicates the area of maximum destruction in these twenty-eight cases. It was impossible to localize the point of initial destruction in any more detail.

PREOPERATIVE PERIOD

The authors' present plan of preoperative treatment consists of general measures designed to build up the general health of the patient, and of local measures designed to afford complete rest of the hip. Both of these phases of the treatment are continued until the patient's general condition is good, until all other foci of tuberculosis are quiescent, and until the patient has demonstrated his ability to combat the hip tuberculosis successfully. Because of the fact that, in the earlier years covered by this report, the arthrodesis was performed soon after the diagnosis was made, only 61 per cent. of the patients in this series obtained preoperative management consistent with present standards. For the entire group the average duration of preoperative treatment was thirteen months. The patients under eight years of age were treated for an average of twelve months before operation; those operated upon between the ages of eight and eighteen had an average of twenty-two months of preoperative care; and those with arthrodeses performed after the age of eighteen had an average of five months of treatment prior to operation.

TABLE I

SEVENTY-SIX PATIENTS WITH TUBERCULOSIS OF THE HIP.

AGE INCIDENCE

Age Range (*Years*)	No. of Cases	Per Cent.
0- 9	36	47
10-19	22	29
20-29	7	9
30-39	5	7
40-49	3	4
50-59	3	4
Total	76	100

In one patient during the preoperative treatment, tuberculosis developed in the opposite hip joint. Both hips were subsequently arthrodesed and excellent results were obtained.

The roentgenographic studies of sixty-four patients during the period of conservative treatment before the arthrodesis revealed some interesting findings. In the patient with the negative roentgenogram on admission destructive changes gradually developed within the hip joint. Forty-seven per cent. of the patients showed no change in the roentgenograms, 11 per cent. showed improvement, 23 per cent. showed progression of destructive changes, and 19 per cent. presented progression of destructive lesions followed by improvement.

One adult patient presented an area of destruction in the lateral cortex of the greater trochanter without apparent hip-joint involvement on admission. Following saucerization of this area, which was proved tuberculous by microscopic sections, there was a gradual spread of the infection to the hip joint.

TABLE II

SEVENTY-SIX PATIENTS WITH TUBERCULOUS ARTHRITIS OF SEVENTY-SEVEN HIPS.

AGE AT TIME OF ARTHRODESIS

Age Range (*Years*)	No. of Cases	Per Cent.
2- 5	10	13
6-10	24	31
11-15	13	17
16-20	12	16
21-30	7	9
31-40	5	6
41-50	3	4
51-56	3	4
Total	77	100

TABLE III

FIFTY-NINE PATIENTS WITH TUBERCULOSIS OF THE HIP.
FATE OF EXTRA-ARTICULAR BONE GRAFTS AT FINAL EXAMINATION

Condition of Graft	No. of Cases	Per Cent.
Non-union of graft to ilium	1	2
Non-union of graft to trochanter	8	13
Fracture of graft	3	5
Destruction of graft	7	12
Sequestration of graft	1	2
Solid incorporation of graft	39	66
Total	59	100

OPERATIVE PERIOD

Table II presents the ages at which the operation was performed. About two-thirds of the patients (64 per cent.) had the arthrodesis between the ages of six and twenty. The youngest age at which the arthrodesis was performed was two years, and the oldest was fifty-six years.

The type of operation varied. An extra-articular arthrodesis was done in 53 per cent.; an intra-articular arthrodesis with extra-articular grafts was the choice in 30 per cent.; and an intra-articular arthrodesis was performed in 14 per cent. The type of procedure could not be ascertained in two cases. The operations were performed by fifteen different surgeons. The Hibbs operation constituted 60 per cent. of the extra-articular arthrodeses.

Following operation, surgical shock was an immediate complication in four cases (5 per cent.), and caused death in two patients (3 per cent.), both of whom were children, aged three and nine, respectively. Secondary infection followed by local sepsis of the operative wound occurred in one case.

POSTOPERATIVE PERIOD

The average time that the hip was completely immobilized in a plaster hip spica postoperatively was ten months. The average time that the hip was immobilized in a plaster hip spica, plus the time spent in some other form of splinting, was nineteen months.

A fracture of the femur, usually in the subtrochanteric area, of the affected side was a complication in four cases (5 per cent.).

In those patients in whom an ankylosed hip developed, the average time after operation required for clinical ankylosis was fifteen months, and for bony ankylosis as shown by roentgenograms, sixteen months.

The fate of the extra-articular bone grafts could be judged in fifty-nine cases. This is depicted in Table III.

A second arthrodesis was performed in twelve patients (16 per cent.), because the hip had failed to become ankylosed. Five of these cases occurred in the group of patients operated upon before the age of eight years

and five occurred in adults. Eighty-three per cent. of these operations were extra-articular arthrodeses, and the remainder were intra-articular in type. One patient, who had the primary arthrodesis at the age of four, had a second arthrodesis at five years, and a third at six. A fibrous type of ankylosis with excellent function resulted.

PATHOLOGICAL AND BACTERIOLOGICAL STUDIES

A microscopic examination of the tissue removed from the hip joint at operation was made in the seventy-six cases; in sixty-five (86 per cent.) the pathological change was diagnostic of tuberculosis. In the remaining eleven cases (14 per cent.) no evidence of tuberculosis could be found.

Laboratory examinations of material removed from the hip joint at the time of operation, or of exudate aspirated from a cold abscess originating from the hip joint at some time during the patient's treatment, revealed the presence of tubercle bacilli in 90 per cent. of twenty-nine cases. These examinations, which usually consisted of a smear, culture, and guinea-pig inoculation, were negative in three cases (10 per cent.). The eleven cases having no evidence of tuberculosis by microscopic examination of tissue were proved tuberculous by these bacteriological studies.

Although the laboratory studies were done in a smaller series of cases, this report tends to show that this method of substantiating the diagnosis will yield as high a percentage of positive diagnoses as the microscopic examination of tissue.

PULMONARY FINDINGS

On admission 53 per cent. of the patients presented roentgenographic evidence of pulmonary tuberculosis. Thirty-eight per cent. were considered to have inactive parenchymal lesions or inactive tuberculosis of the hilar lymph nodes; 12 per cent. had active tuberculosis of the lungs or hilar nodes; and in 3 per cent. the chest lesions were questionably active.

Children under eight years of age revealed the highest incidence (72 per cent.) of pulmonary tuberculosis, and this was usually interpreted as an inactive hilar lymph-node infection.

There were three patients who had active, minimal, pulmonary tuberculosis at the time of operation. After operation this infection became inactive in two of these patients. About two years postoperatively a marked increase in the pulmonary tuberculosis developed in the third patient and was followed by a spread of the infection to the shoulder and mastoid process, and by sinus formation about the hip. Death occurred three years after operation.

Four patients apparently had active tuberculosis of the hilar glands at the time of arthrodesis, but this infection gradually subsided after operation.

At the time of the final examination of the patients who survived, no instance of active pulmonary tuberculosis was recorded.

OTHER TUBERCULOUS LESIONS

Ten patients (13 per cent.) in this series had other tuberculous lesions of bone at some time while under the authors' observation. The end results in the hip joints in this group compared very closely with the results for the entire series. These lesions were distributed as follows: spine, six cases; shoulder and mastoid process, one; opposite hip joint, one; head of the radius, one; and hard palate, one. One of these ten patients also had bilateral renal tuberculosis, and tuberculous meningitis developed in a second.

In the remaining sixty-six cases there were only two instances of other tuberculous lesions; one patient had unilateral renal tuberculosis and the other had tuberculous peritonitis.

There was a direct relationship between the age of the patient and the occurrence of these foci. This incidence was 8 per cent. in patients under eight years of age; 15 per cent. between eight and eighteen years; and 25 per cent. in patients over eighteen years of age.

TABLE IV

SCALE OF SUBJECTIVE AND OBJECTIVE END RESULTS IN PATIENTS WITH TUBERCULOSIS OF HIP

Grade	Subjective	Grade	Objective
I	Good general health; painless hip; satisfactory gait; normal activities; rehabilitated.	A	Good general health; solid clinical ankylosis of hip in good position; no clinical or roentgenographic evidence of active infection; good gait; roentgenographic evidence of bony ankylosis of head to acetabulum and solid incorporation of bone graft.
II	Same as (I) except for occasional mild aching in hip.	B	Same as (A) except for roentgenographic evidence of solid incorporation of extra-articular graft, but no ankylosis of head to acetabulum.
III	Good general health; episodes of hip pain which require cessation of activities; fair gait; otherwise rehabilitated.	C	Same as (A) except for fibrous ankylosis of hip shown by clinical and roentgenographic examination.
		D	Good general health; fibrous ankylosis of hip; no abscess; occasional discharge from sinus; fair gait; no roentgenographic evidence of activity.
IV	Poor general health due to hip infection; persistent or frequent attacks of hip pain; poor gait; semi-invalid or invalid.	E	Poor general health; irritable; movable hip; active sinuses; recurrent abscesses; active tuberculosis of hip; secondary pyogenic osteomyelitis of hip; poor gait.

TABLE V

END RESULTS IN PATIENTS WITH TUBERCULOUS ARTHRITIS OF THE HIP

Results	Subjective * (71 Patients with 72 Hips)			Objective ** (70 Patients with 71 Hips)		
	Grade †	No.	Per Cent.	Grade †	No.	Per Cent.
Excellent	I	42	58	A	24	34
Good	II	10	14	B	13	18
Fair	III	1	2	C and D	16	23
Poor	IV	6	8	E	5	7
Deaths		13	18		13	18
Totals		72	100		71	100

* Results in 5 patients were unknown. ** Results in 6 patients were unknown.
† See Table IV.

END RESULTS

The results in this series of cases are based upon the history, and clinical and roentgenographic examinations. The average time elapsed from operation to the final symptom examination (questionnaire) was seven years and five months. The average time elapsed from operation to the final clinical and roentgenographic examinations was five years. The subjective end-result study is, therefore, based upon a postoperative period two years and five months longer than the objective end-result study.

Due to the many variations in symptoms, in the clinical picture, and in roentgenographic findings that occur in cases of tuberculosis of the hip, the results are somewhat difficult to classify. The final classification was facilitated and elucidated by first grouping the cases into subjective and objective end results.

TABLE VI

COMPOSITE END RESULTS IN SEVENTY-ONE PATIENTS WITH TUBERCULOUS ARTHRITIS OF SEVENTY-TWO HIPS *

Result	Composite Grade †	No. of Cases	Per Cent.
Good	I A I B II A II B	37	52
Fair	I C II C III D	16	22
Poor	IV E	6	8
Deaths		13	18
Total		72	100

* Results in 5 patients were unknown. † See Table IV.

Table IV presents the different gradations of subjective and objective findings upon which the subjective and objective end results are based.

Table V presents the subjective end results in seventy-one patients and the objective end results in seventy. Patients could not be traced for a sufficient period to judge the subjective results in five cases, and the objective results in six. It is noteworthy that 72 per cent. of the patients were rehabilitated and had good or excellent subjective results from a symptomatic standpoint. The mortality of 18 per cent. emphasizes the seriousness of this disease. The objective results were judged from clinical and roentgenographic examinations. Excellent or good results constitute 52 per cent. of the total cases. It is seen that from the objective standpoint the excellent or good results have diminished and the fair results increased, as compared to the results from the symptomatic or subjective standpoint. This difference is due largely to the authors' reluctance to classify a fibrous ankylosis as better than a fair result, even though in other respects the result is entirely satisfactory.

Table VI demonstrates the composite end result by combining the subjective and objective end result in each case. It will be seen that the composite results closely approximate the objective results. Considering a combination of subjective Grade I and objective Grade A (Table IV) as the ideal type of result in tuberculosis of the hip, it was found that 32 per cent. of the total attained this result. Of the 22 per cent. making up the fair results, there were 13 per cent. of the total series who were rehabilitated and had an excellent result in every respect, except that by the roentgenogram there was no bony ankylosis (composite Grades I and C, Table IV). The authors have seen develop in this type of hip an exacerbation of the tuberculous infection late in the course of the disease. It is their feeling that a fibrous ankylosis following tuberculosis in a weight-bearing joint is apt to be an insecure ankylosis, and an insecure ankylosis is more prone to reactivation of the tuberculous process. For these reasons it is classed as a fair result.

The varying results obtained in the different age groups is of considerable interest. The group of patients who had an arthrodesis performed before the age of eight obtained end results which were practically identical with the average of the entire series; those patients having an arthrodesis between the ages of eight and eighteen had results which were considerably above average; and those having an arthrodesis after the age of eighteen obtained results considerably below the average for the entire series. It is apparent that the patients with the longer preoperative care obtained the better results.

Analysis of Patients with Poor Results

Six patients (8 per cent.) of the entire group had poor results. Three of these patients were under five years of age and the remaining three were over thirty years of age. The treatment of each patient prior to

operation might be subject to criticism in one or more respects, if judged from the present conception of the requirements of preoperative treatment as alluded to previously. The average age at the time of operation was four years and six months in the children and forty-six years in the adults. The most striking fact concerning the end results in these patients is the high incidence of secondary pyogenic infection of the hip with sinus and recurrent abscess formation, associated with persistent pain and absence of ankylosis. Four of the six patients had this type of result; the remaining two complained of persistent pain and showed increasing destruction of the hip without ankylosis.

TABLE VII

ANALYSIS OF DEATHS DUE TO TUBERCULOSIS OR ITS COMPLICATIONS

Case	End Result in Operated Hip	Forms of Active Tuberculosis Present	Cause of Death
1	Excellent	Tuberculosis of opposite hip, pulmonary tuberculosis, tuberculous meningitis	Tuberculous meningitis
2	Poor	Mixed tuberculous and pyogenic osteomyelitis of the hip with sinus formation	Prolonged suppuration, and amyloidosis
3	Poor	Mixed tuberculous and pyogenic osteomyelitis of the hip with sinus formation, pulmonary tuberculosis, tuberculosis of shoulder, tuberculous enteritis, and tuberculous mastoiditis	Prolonged suppuration, pulmonary tuberculosis, and disseminated tuberculosis
4	Poor	Mixed tuberculous and pyogenic osteomyelitis of the hip with sinus formation	Prolonged suppuration
5	Poor	Mixed tuberculous and pyogenic osteomyelitis of the hip with sinus formation, tuberculosis of the spine, and tuberculous enteritis	Prolonged suppuration

Analysis of Deaths

The total mortality of 18 per cent. (thirteen patients) consisted of deaths due to unrelated diseases or unknown causes (8 per cent.), deaths resulting from operative shock (3 per cent.), and deaths due to tuberculosis (7 per cent.).

The tuberculous involvement and the cause of death in each of the five patients dying as a result of tuberculosis or its complications are shown in Table VII. The high incidence (80 per cent.) of active mixed tuberculous and pyogenic osteomyelitis of the operated hip with sinus formation is noteworthy. Three of these four patients were over the age of eighteen and represent the total mortality in this age group. These facts demonstrate the serious nature of secondary infection in joint tuberculosis.

Analysis of Cases with Cold Abscesses

In thirty patients (39 per cent.) out of the entire series a cold abscess formed about the hip region at some time during their illness. In twenty-six (87 per cent.) of these, the abscess appeared for the first time prior to the operation. Nine patients gave a history of an abscess which had disappeared before admission. Nine patients presented an abscess in the hip region on initial examination. During the preoperative period, abscesses formed about the hip in eight additional patients. The abscess subsided prior to the arthrodesis in all but two patients, who had this operation performed in the presence of the abscess. It is important to note that the average duration of preoperative care in the patients in whom abscesses were observed was approximately twice that of the general average. This fact may have had a beneficial effect upon the final results in these patients.

The initial abscess formed after the arthrodesis in four (13 per cent.) of the thirty patients. In only three of the twenty-six patients who had an abscess before operation did this complication develop postoperatively.

There was no patient with abscess formation at the time of the last clinical examination, although a few gave a history of recurring abscesses which were associated with sinus formation and secondary infection.

The results in the twenty-four patients with abscess formation while under observation did not differ materially from those of the entire series, which would imply that a tuberculous abscess does not render the prognosis more serious.

However, since a cold abscess may often be followed by sinuses and secondary infection, the importance of this complication must never be minimized. In 79 per cent. of the twenty-four patients in whom tuberculous abscesses were demonstrated, sinuses subsequently developed in spite of prompt and efficient treatment. The abscess subsided without sinus formation in only 21 per cent. of the cases.

The two patients who had the arthrodesis in the presence of a cold abscess later developed active sinuses, recurrent pyogenic abscesses, and secondary hip-joint infection. These complications contributed to the death of one of these patients, and have persisted in the other. The formation of a cold abscess is evidence of activity of the tuberculous infection, and operation should be delayed until the abscess has disappeared.

Analysis of Cases with Sinus Formation

In forty-three patients, or 57 per cent. of the entire series, a sinus or sinuses developed in the hip region at some time during the illness.

Sinuses formed in eighteen patients or 42 per cent. of this group previous to operation. Three patients gave a history of sinuses which had healed prior to the authors' observation. The initial examination disclosed seven patients with sinuses. Sinuses developed preoperatively in nine additional patients, one of whom had had sinuses before coming to this hospital. Thus, sixteen patients presented this complication while

under the authors' care, before operation. In eleven of them the sinuses healed before the arthrodesis was undertaken, but in five the operation was done in the presence of sinuses. The average duration of preoperative care for these sixteen patients was two and one-half times the average for the entire series.

In twenty-five patients, or 58 per cent. of this group, sinuses developed initially after the arthrodesis; while six patients, who had sinuses prior to operation, had a recurrence of this complication after operation. Thus, thirty-one patients presented sinuses at some time after operation. It must be emphasized that in three (60 per cent.) of the five patients operated upon in the presence of sinuses other sinuses developed after operation. These facts demonstrate that patients having sinuses before operation are not predisposed to the development of sinuses after operation, unless the operation is carried out before the sinus has healed.

At the time of the final examination, the sinuses had healed in 58 per cent. of the thirty-one patients and had persisted in thirteen, or 42 per cent. Seven of these thirteen patients were adults. Four of the patients with persistent sinuses had had sinuses both before and after operation; in nine the sinuses developed initially following operation.

The end results in the forty-three patients having sinuses at some time during their illness did not materially differ from those of the entire series. This was equally true for those patients having sinuses only preoperatively or only postoperatively. However, sinus formation in patients over the age of eighteen was associated with inferior results.

The five patients having the operation in the presence of sinuses had results definitely inferior to the average for the entire group, and three of these five had persistent sinuses.

The end results of the thirteen patients who had persistent sinuses are considerably inferior to those of the entire series. In three patients the results were very satisfactory, except for a slight intermittent discharge from a sinus, and they were classed as good. (These are the only instances in which the grading as presented in Table IV was not strictly adhered to.) Fair results were obtained in two of these patients. In each of the four patients who had a poor result, and in each of the four who died, there was an actively draining sinus with secondary pyogenic infection of the hip joint.

Considering the entire series of cases irrespective of sinus formation, there were six patients with poor results, four of whom had active sinuses with secondary pyogenic hip-joint infection. Thirteen patients in the entire series died, and only five of these died of tuberculosis or its complications. Four of these five patients had secondary infection of the hip with active sinuses, and in each instance this complication was either directly responsible for or was a contributing factor in the mortality.

It can be concluded, that the occurrence of sinuses communicating with a hip joint which is the site of a tuberculous infection may be a very grave complication. In this series the patients with poor results and the

patients who died showed a high incidence of persistent sinus formation with secondary hip-joint infection.

POSSIBLE FACTORS IN THE END RESULTS

A careful study of each case in this series was made in an attempt to discover what factors might be of importance in determining the type of end result obtained. If a certain factor occurred in a sufficient number of cases and was associated with end results which were significantly above or below the average for the entire series, it was believed important. The factors which seemed worthy of mention in this regard are as follows:

1. Preoperative care of six months or longer was associated with much better results.

2. If the arthrodesis was not done before the age of eight years, the outlook was more favorable.

3. The results were less favorable in the group of patients over the age of thirty.

4. The presence of active pulmonary tuberculosis, or of a sinus or cold abscess about the hip, at the time of operation was associated with more unfavorable results.

5. The degree of destruction as seen in the roentgenograms on admission did not bear any relation to the end result.

6. If, during the preoperative treatment, the serial roentgenograms revealed improvement in appearance, or progression in destructive changes followed by improvement, the prognosis was better.

7. Progression of destruction seen in the roentgenograms preoperatively was an unfavorable factor, if the patient had had less than six months of conservative care; but, if the patient had had more than six months of treatment, the results were about the same as the general average. This is in contrast with factor 6, where, with conservative care continued until roentgenographic evidence of improvement was noted, the end results were better than average.

8. The type of arthrodesis performed did not apparently influence the end result except in the case of the intra-articular arthrodesis without bone grafts. Only seven patients in whom this operation was done were followed sufficiently for an end-result study. In these the results were inferior to the general average.

9. Sinuses about the hip persisting after arthrodesis were associated with inferior results.

10. The adverse effect of active secondary pyogenic infection of the hip joint has already been discussed.

11. Adult patients with sinuses about the hip had a less favorable prognosis than younger patients with this complication.

THE OPTIMUM TIME FOR ARTHRODESIS

From a study of these factors an optimum time for the performance of the arthrodesis may be proposed. The patient should have had six months or more of preoperative treatment. This treatment should be

continued until: (1) the patient is at least eight years old; (2) any abscess or sinus about the hip has disappeared; (3) there is no evidence of active pulmonary tuberculosis; and (4) there is roentgenographic evidence of improvement in the lesions.

SUMMARY

In a review of seventy-six patients with proved tuberculous arthritis in seventy-seven hip joints treated by arthrodesis, the end results were good in 52 per cent. (thirty-seven patients), fair in 22 per cent. (sixteen patients), poor in 8 per cent. (six patients), and the total mortality was 18 per cent. (thirteen patients). The result was unknown in five patients. Both general and local therapy, designed to improve the general health and to furnish complete rest to the hip, is recommended for considerable periods both before and after operation. This study supports the contention that the arthrodesis should be done at an optimum time in the course of the disease. The seriousness of mixed tuberculous and pyogenic infection of the hip is stressed by the incidence of this complication in the poor results and deaths. The age of the patient, the duration of preoperative care, sinuses, abscesses, changes as shown by roentgenograms, type of arthrodesis, and pulmonary tuberculosis influenced the end results in this series of cases.

THE PELVIFEMORAL ANGLE

Determination of Hip-Flexion Deformity

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Measurement of the degree of flexion deformity at the hip joint is one of the most elementary of orthopaedic procedures. Not only is it fundamental to the making of accurate records, but it is of vital importance when the question of osteotomy for the correction of the deformity arises. Yet, strange as it may seem, no satisfactory method has been devised for determining this with even a fair degree of accuracy.

Present practice consists of placing the patient in the supine position and of flexing the unaffected leg, until, in the opinion of the examiner, the lumbar curve is obliterated. The flexion present in the affected limb is then determined by subtracting its maximum degree of extension from 180 degrees; in effect this is the equivalent of the degree of elevation of the affected limb above the level of the examining table.

FIG. 1

The patient is supine. The lumbar curve is obliterated and the well leg has been flexed. The flexion deformity of the right hip appears to be 25 degrees.

FIG. 2

By further increasing the flexion of the well leg, the flexion deformity of the right leg appears to have been increased to 35 degrees. The photographs of Figs. 1 and 2 were made consecutively.

This procedure is not dependable, even for clinical purposes. In the first place, it is almost impossible for different examiners to agree on the extent to which the opposite leg should be flexed adequately to obliterate the lumbar curve. In the second place, it is impossible for any individual to be certain that the same position has been obtained at any two consecutive examinations of the same patient. Disturbing confirmation of this assertion was obtained in a recent examination of the same patient by seven colleagues. Each arrived at an entirely different estimate of the degree of flexion contracture, and the results varied from as little as 10 degrees to as much as 50 degrees. The explanation of this wide variation is apparent from a study of Figures 1 and 2, which were taken during the course of this test. In both figures the lumbar curve has been obliterated, but in Figure 1, the left, unaffected leg, is obviously in less flexion than in Figure 2. As a consequence, the flexion deformity of the right hip appears to be less in Figure 1 than in Figure 2. Since the effect of greater flexion of the well leg is to decrease the forward inclination of the pelvis, it is evident that the diversity of the expressed opinions was due to the fact that each examiner was measuring the flexion of the hip *plus* a variable degree of flexion of the pelvis.

This forms the basis of the main objection to the current method. The method does not, in truth, measure the flexion deformity of *the hip*. At best, it estimates the total degree of combined *hip and pelvic flexion*. In other words, it merely determines the amount of hip extension possible at any given degree of pelvic flexion. Since this latter cannot be fixed as a standard of reference, the whole procedure loses its validity. What is needed is a test by which the flexion component of a hip deformity can be measured with respect to fixed anatomical landmarks. The first step in arriving at such an end obviously is the concise definition of the term, "flexion deformity of the hip". Most certainly the term is not intended to define a relationship between a patient's hip and the physician's examining table. If it has any significance at all, it must be to describe the position of the patient's hip with respect to the pelvis, to which it is attached. Fortunately, such an intrinsic relationship can be established.

Before this can be undertaken, it must be recalled that the primary relationship between pelvis and femur is determined *in utero* in the attitude of universal flexion. In this position, the pelvifemoral soft structures and especially the Y-shaped ligament develop. Due to the fact that the ligaments and flexor muscles of the hip do not yield, they impose a definite limit to the relative extension which is possible between the femur and the pelvis. This is not sufficient to permit normal bipedal progression. As a consequence, after birth and with the progressive assumption of the erect position, the pelvis is gradually tilted forward and downward, and the lumbar lordosis develops. (This is the basis of the obstetrical manoeuvre originally recommended by Walcher for the purpose of aligning the axis of the pelvic inlet with the axis of the foetal head. It is similarly the reason why Bryant's overhead traction, instead of straight extension

traction, is indispensable in treatment of children in whom the lumbar curve has not yet developed.)

The amount of forward inclination of the pelvis will, of course, depend in large measure upon the relative length of the pelvifemoral binding structures. Where the ligaments are longer, the forward inclination of the pelvis will be less when the legs are in the erect position; where they are shorter, the inclination will be greater. In any event, it is clear that with the legs in normal extension, any further extension of the femora is accomplished only as a result of increased forward flexion of the pelvis.

According to Steindler, the amount of this forward flexion is such that in the erect position, "a plane may be laid through the anterior superior spines of either side and through the upper edge of the symphysis. In the upright standing position this plane will be a true frontal plane." This is a very important observation, because it establishes the fact that in the vertical position the extended legs lie in a plane parallel to the frontal plane of the pelvis. But since this plane cannot easily be determined by clinical examination, it was found desirable to use another plane, the so-called axial plane. This is defined by Steindler as "a plane laid through both anterior superior spines and both tubera ossis ischii".

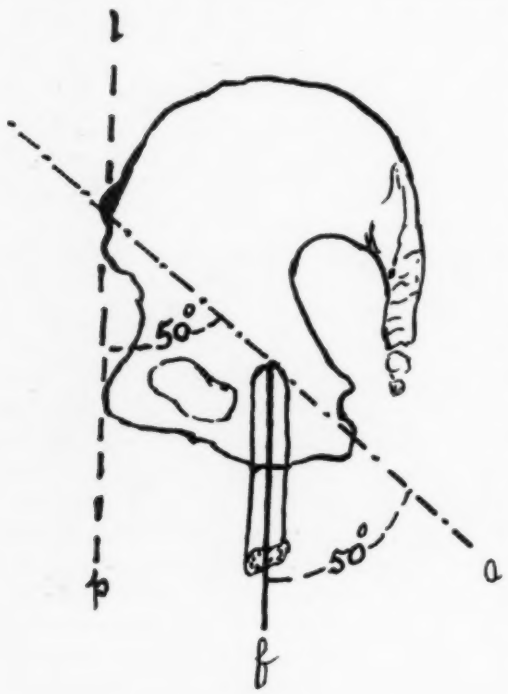

FIG. 3

Outline of pelvis, indicating the relationship of the extended femur (*f*) to the frontal plane of the pelvis (*p*) and to the axial plane of the pelvis (*a*).

Because of the fact that the axial inclination of the pelvis originates as a result of extension of the legs, it follows that any increase in the axial angle must be accomplished at the expense of an increased lumbar lordosis. Since the extension of the femur with respect to the pelvis is limited, it follows that the angle which the extended femur makes with the axial plane is also limited. It is interesting to note that the outer edge of this plane, from the anterior superior spine to the tuberosity of the ischium, is *Nélaton's line*, and can be readily outlined on the skin. The axis of the extended femur makes, with Nélaton's line, an angle opening downward and backward, which is determined by easily palpable bony

landmarks. This angle, which may be called the pelvifemoral angle, is a true measure of the extension of the femur on the pelvis.

According to Steindler, the axial plane, in the erect position, makes an angle of about 50 degrees with the frontal plane of the body. In the erect position, the legs similarly lie in the frontal plane, and it follows, therefore, that the axis of the extended femur makes with Nélaton's line —in the axial plane—a pelvifemoral angle, amounting to about 50 degrees (Fig. 3). In actual practice, this measure has been found mainly in adults. It has particular application when both hips are flexed, and no norm for the individual can be established. This figure, however, is not absolute. In children, for example, it has been found to vary considerably, and further studies are being conducted to determine the conditions under which the angle may vary.

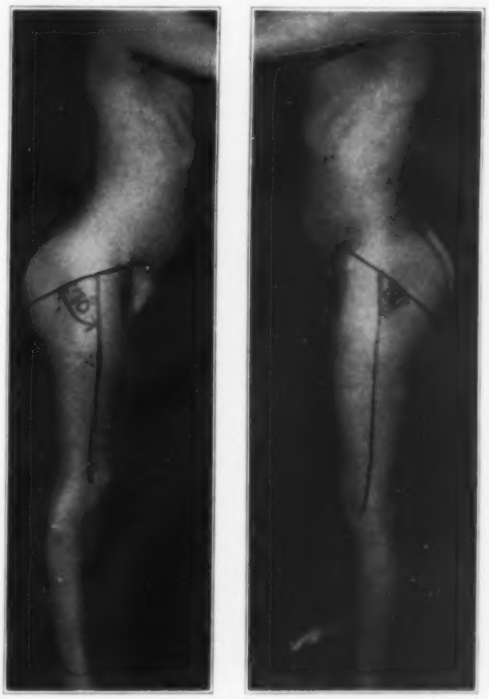

FIG. 4-A FIG. 4-B

In the erect position, the patient seen in Figs. 1 and 2 has been marked to indicate the extension angle on the right side, 70 degrees, and on the left side, 50 degrees, for comparison. The difference, 20 degrees, measures the flexion deformity of the right side.

Bearing these observations in mind, the method here suggested presents itself, not as a fanciful innovation, but rather as a logical necessity. The two bony landmarks, the anterior superior spine and the tuberosity of the spine, are marked on the skin, and a line representing Nélaton's line is drawn between the points. Except under circumstances previously discussed [1] the tip of the trochanter lies upon this line. From the trochanter a line is drawn upon the extended thigh along the axis of the femur. The downward and backward directed angle which these two lines determine, is the pelvifemoral angle. Any increase in the size of this angle beyond the normal 50 degrees is the measure of the limitation of hip extension,—that is, of the flexion of the hip under consideration. Whether the patient be erect or recumbent, whether the spine be arched or flat, whether the pelvis is tilted up or down or sideways, this angle will remain constant, for any given patient with hip extended. Though 50 degrees is considered normal, there may, of course, be individual variations. To rule out the possibility of such variants, the angle of maximum extension of the un-

affected hip should be ascertained. The difference between this angle and the corresponding angle on the involved side will establish the amount of flexion deformity (Fig. 4).

FIG. 5-B FIG. 5-A

Fig. 5-A: The device consists of a thigh piece hinged to a flexible pelvic band, which can be made to follow Nélaton's line.

Fig. 5-B: Illustrates the method of application for clinical determination. The patient is photographed in the erect position. In clinical practice, the patient may be examined in any position, provided the affected limb is in maximum extension.

For somewhat more objective measurements, a simple device has been constructed (Fig. 5-A). The device consists of a piece of metal which can be strapped to the outer side of the leg, with its upper end at the level of the tip of the trochanter. The flexible lead strip, which fits into a slot, attached to the upper end of the thigh piece, is laid down so as to span the distance between the anterior superior spine and the tuberosity of the ischium. The flexion angle can then be promptly read from a protractor which is fixed to the thigh piece (Fig. 5-B). The apparatus is simple to make and insignificant in cost. It affords a fairly accurate means of measuring the relationship of the thigh to the pelvis, in a manner sufficiently objective to be of value for comparative studies or for court purposes.

Naturally enough, the possibility of making and permanently recording this data by means of routine roentgenograms of hip and pelvis suggested itself. After repeated trials, using different technical devices, this method had to be abandoned as inaccurate. The explanation for this inaccuracy is to be found in Figures 6-A and 6-B. A wire triangle, along with the shadow it cast under a strong light, were photographed, simultaneously. The wire was used to represent the skeletal landmarks, the bright light to represent the roentgen beam, with the shadow the roentgenogram normally produced. In Figure 6-A, the plane of the triangle was held approximately perpendicular to the central beam. It will be seen that in general the photographic shadow is similar to the wire triangle. In Figure 6-B the triangle has been rotated out of the perpendicular into an oblique plane. As a result, the size of the triangle and the dimensions of the angles have been changed to a degree proportional to the relative angle of rotation either of the central beam or of the object under examination.

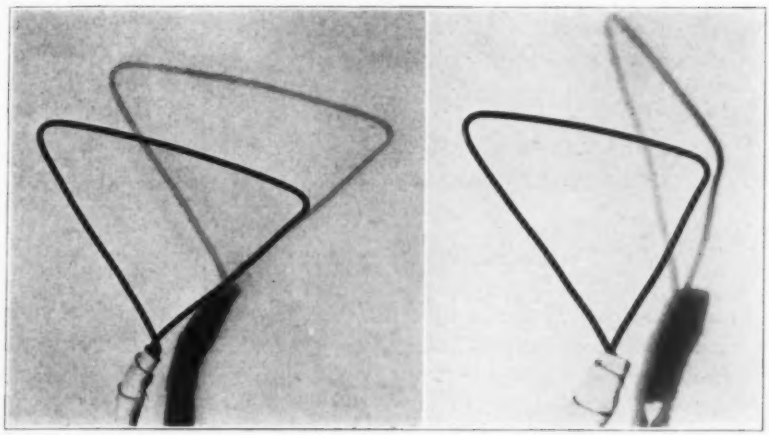

FIG. 6-A FIG. 6-B

A wire triangle, with the shadow which it casts, has been photographed to show the relationship between the size of the shadow and rotation of the plane of the triangle.

Fig. 6-A: The triangle is in a plane perpendicular to the central beam. The dimensions of the shadow closely approximate the actual size of the triangle.

Fig. 6-B: The plane of the triangle is oblique to the central beam. The resultant distortion of the size and angular dimensions is obviously proportional to the degree of relative rotation between the plane of the triangle and the central beam of light.

From the similarity between this and a roentgenographic projection, it is clear that distortion of the angles formed between bony landmarks must occur, unless the plate is parallel and the central beam is perpendicular to the plane in which the parts lie. Because of the fact that Nélaton's line is curved in space, this is impossible and reliance must be placed upon the clinical measurement previously described.

SUMMARY

The present method of estimating hip-flexion deformity is inaccurate because it is a measure of hip flexion plus pelvic flexion. The simple device described in this article has been found valuable in determining, from anatomical landmarks, the degree of hip flexion in relation to the pelvis.

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EXTERNAL SKELETAL FIXATION IN FRACTURES OF THE MANDIBULAR ANGLE

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Fractures involving the angle of the mandible and producing an edentulous posterior fragment often present a difficult problem in reduction. This difficulty is due mainly to the displacement of the posterior fragment, and is caused by the location and the direction of the fracture line (Fig. 1). If the fracture line is situated in the angle in the midst of the insertions of the masseter and internal pterygoid muscles, the displacement may be minimal, as the fragments are splinted by the muscular insertions. If the fracture line runs anteriorly to the insertions of these muscles, the posterior fragment will be pulled upward and forward by their contraction (Fig. 2). This displacement is facilitated when the

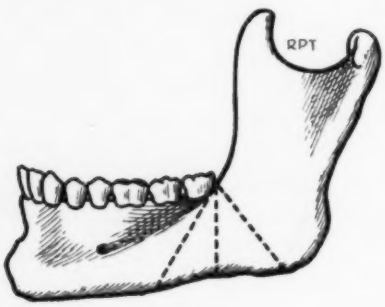

FIG. 1

Diagram illustrates various directions assumed by the fracture line at the angle of the mandible.

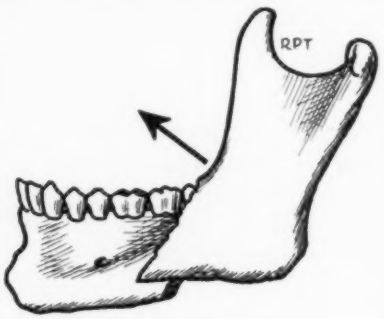

FIG. 2

Diagram illustrates the frequent displacement forward, upward, and outward of the posterior fragment.

fracture line is vertical or directed downward and backward. It may be diminished when the direction of the fracture line is downward and forward, as the posterior fragment may be stopped in its upward movement by the anterior fragment which acts as a buttress. Usually, however, the displacement upward and forward is increased by the bevel of the fracture line which causes a displacement of the posterior fragment inward, or outward, thus eliminating the buttress action of the anterior fragment (Fig. 3). This displacement of the posterior fragment may be so marked as to prevent the occlusion of the jaws.

Various methods have been used to reduce this type of fracture. A block of stent, gutta-percha, or vulcanite, putting pressure on the posterior fragment, with the jaws wired in occlusion, was the first method used

(See references 1, 4, 5, 6, 7, 12, 17, 18, 20, 21, 22, 23). Open reduction with bone suture has been used (See references 8, 11, 13, 14), but in many cases reduction is difficult to obtain and maintain by the means of a wire because of the strong muscle pull, particularly if the reduction is done late. A forked-wire lever, based upon a capped splint in the lower molar region and pressing upon the anterior border of the ascending ramus [11], a similar device based upon an upper crown [3], or a jackscrew attached to a superior vulcanite splint [4] have given satisfactory results, but present the common inconvenience of causing localized ulceration of the mucosa and even bone necrosis. Traction exerted upon a wire passed through a drill hole in the angle of the mandible, after exposure of the latter through a small incision, and based upon a plaster head-cap has become the most favored method of treatment (See references 5, 9, 12, 16, 17, 19). While satisfactory in many cases, the method lacks precision and the apparatus is cumbersome. It was felt that some method which would allow more complete control of the fragment was desirable.

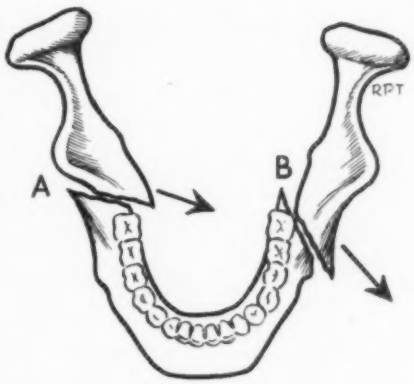

FIG. 3-A

Diagram shows displacement of the posterior fragment medially or laterally according to the bevel of the fracture line.

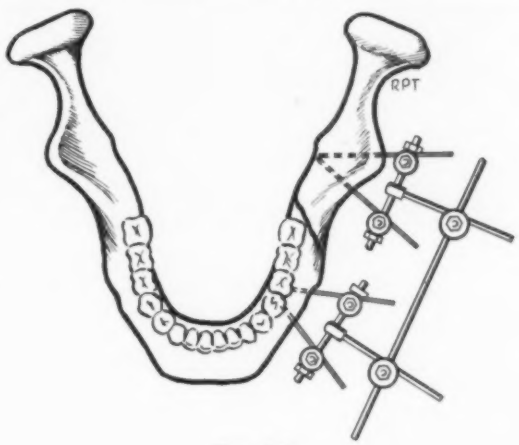

FIG. 3-B

Diagram illustrates reduction by external fixation.

EXTERNAL FIXATION

In the Orthopaedic Unit of the American Hospital in Britain, the great success of external skeletal fixation in the treatment of fractures of the long bones has led to the use of a small apparatus, constructed by Waknitz on the principle of the Roger Anderson pin unit [2], in the treatment of fractured metacarpal bones. This apparatus was applied for the first time by the authors in the treatment of a fracture of the angle of the mandible in a patient admitted to the Plastic and Jaw Unit of the Emergency Medical Service under the direction of Sir Harold Gillies. Since this method of external skeletal fixation has been adopted with great enthusiasm in Great Britain, the first case in which the method was applied

FIG. 4-A FIG. 4-B

Roentgenograms of mandible show non-union with displacement of edentulous posterior fragment forward and upward. The third molar is in the fracture line.

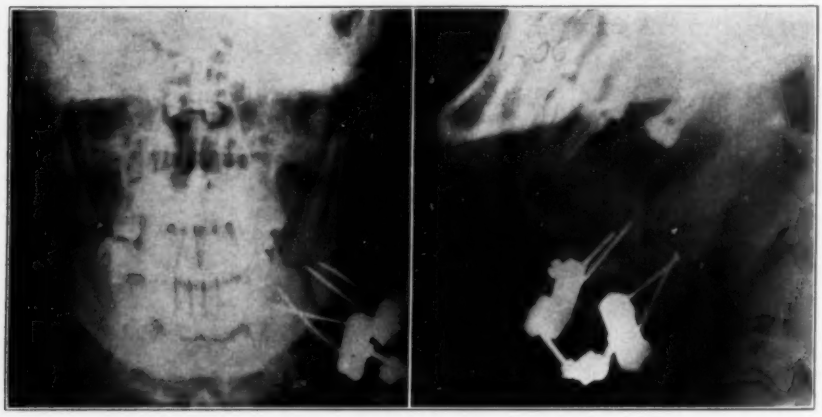

FIG. 5-A FIG. 5-B

Roentgenograms show pins maintaining reduction.

may be of interest.* This operation was done at Rooksdown House, Basingstoke, on January 8, 1941.

CASE REPORT

A soldier, aged twenty-one years, was admitted to the Hospital for treatment of non-union of the left angle of the mandible. He had been injured two months previously and had failed to obtain union under simple conservative treatment. There was a displacement of the posterior fragment laterally, upward, and forward. A third molar had been left in the fracture line (Figs. 4-A and 4-B). On January 8, 1941, two weeks after extraction of the third molar, under general anaesthesia, exposure of the fracture site was made through a small incision below the angle of the mandible. The fibrous tissue between the fragments was resected and reduction of the fracture was attempted by

* Haynes reported a mandibular fracture treated by fixation by means of screws and external bar fixation.[10] Mowlem, Buxton, MacGregor, and Barron have reported a series of cases dating from February 1941, in which this type of treatment has been used with modifications of the fixation unit.[15]

applying traction with a bone forceps to the posterior fragment. Reduction could not be obtained because of the strong pull and shortening of the masseter and of the internal pterygoid muscles. The pins were then drilled into the fragments with an electric drill, two pins into the anterior fragment and two pins into the posterior fragment. The two sets of pin units were joined by the connecting apparatus, and, by the proper manipulation of the latter, reduction was obtained (Figs. 5-A and 5-B). The apparatus was locked, and a small plaster bandage was placed around the pin units for further immobilization. Cotton soaked in collodion was wrapped around the pins to protect the pinholes in the skin. The small incision at the angle of the mandible was sutured with a subcuticular wire. No sepsis occurred around the pins. The wires were left in position for five weeks. During this time, beginning the day after the operation, the patient could open and close his mouth and masticate in a normal fashion. Two days after the removal of the pins, the pin holes in the skin were found to have closed. One week later the scarring left by the pins was barely discernible. The fracture was solidly united with excellent alignment of the fragments (Fig. 6).

FIG. 6

Roentgenogram, lateral view, shows reduced and consolidated fracture after removal of pins.

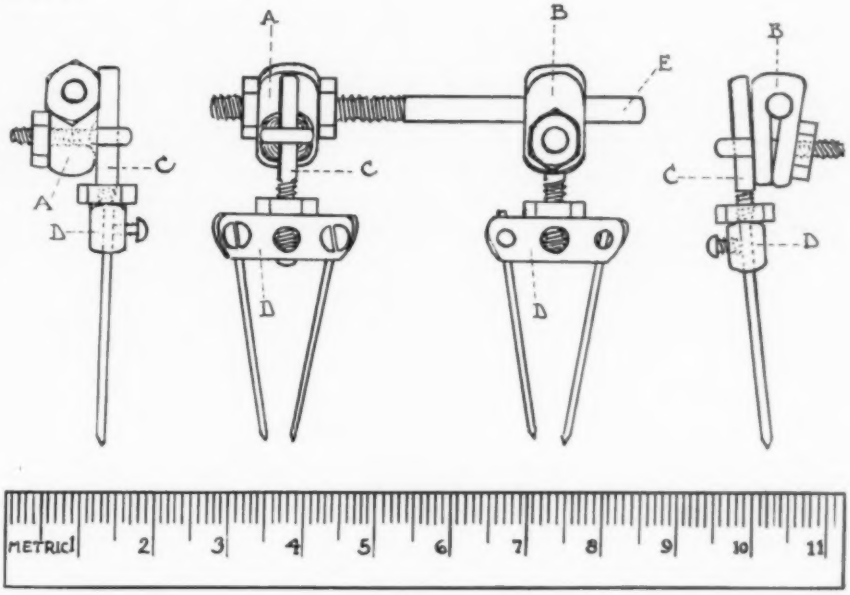

FIG. 7

Diagram of apparatus now being used. The pins are inserted through the pin block *D* and then cut flush with the surface of the block. The pin units are joined by the attachment of universal joints *A* and *B* which are on the rod *E*. Great precision in reduction is obtained because small variations can be made in any one plane without loss of position in the other planes. Note the small size of the apparatus which eliminates the inconveniences of a more cumbersome appliance.

FIG. 8

Roentgenogram of mandible in a patient, aged six years. External fixation cannot be performed because of the presence of the tooth follicles.

An incision was made in this case for resection of the fibrous tissue at the site of non-union. In the average case, the incision is unnecessary and the pins can be introduced without incision, and can be guided in their direction by X-rays and by palpation of the fracture line. Modification of the position of the fragments can be carried out by manipulating the apparatus, and an anatomical reduction should be obtained. The pins are best inserted with an electric drill. Particular care must be taken, both as to the direction of the pins and the depth of insertion, in order not to perforate the mucous membrane of the mouth. The pins must transfix both cortices of the mandible in order to secure firm fixation.

This appliance (Fig. 7) is essentially an adaptation of Roger Anderson's method for fracture fixation by pins connected with an adjustable external bar. A pin block holds two pins placed in a converging position to each other. The pin units are connected by adjustable joints *A* and *B*, and the rod *E*. Various modifications of this apparatus have been tried, but to date this model has proved the most satisfactory. Its construction is extremely simple and within the scope of the average bracemaker. It is so designed that alterations can be made in any one plane without essential loss of position in other planes. The pins should be made of quite rigid stainless-steel wire, similar to Kirschner wire. The angle of convergence of the pins should be not less than shown in the dia-

gram. Modifications of the apparatus can be made by addition of supplemental pin units. This is useful in treatment of multiple fractures of the edentulous mandible.

External fixation is not feasible in children, before the appearance of the permanent dentition, because of the presence of the tooth follicles in the mandible (Fig. 8).

SUMMARY AND CONCLUSIONS

The Roger Anderson method of external skeletal fixation has been adapted for fractures of the edentulous mandible. External skeletal fixation promises to be extremely useful in the compound war wounds with multiple fractures. Each fragment can be controlled by a pin unit while intra-oral care, as well as dressings of the facial wounds, are carried out.

The advantages of the method are that it allows the accurate control of the fragments, and permits the patient to open and close his mouth and to masticate.

The disadvantage of the method is the possibility of infection. Asepsis should be observed during the insertion of the pins and contact with the mouth should be strictly avoided.

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CONGENITAL ABSENCE OF ODONTOID PROCESS OF THE AXIS WITH ATLANTO-AXIAL DISLOCATION

BY HOWARD G. WEILER, M.D., WHEELING, WEST VIRGINIA

Because of its rarity in the literature, another case of congenital absence of the odontoid process of the second cervical vertebra or epistropheus, resulting in atlanto-epistropheal dislocation, is presented. Fusion following reduction was successful. Two years have passed since the operation, and active use of the head and neck have caused no further complications.

A case such as this one was reported by Sumner M. Roberts in 1933, although a fusion operation was not performed, and no further reports were made concerning the patient. Many reports of atlanto-epistropheal dislocations have been made since Coutts reviewed the literature on this subject in 1934. Coutts' report was concerned chiefly with anterior subluxation and rotation of the atlas, but served to direct more attention to the subject of dislocation at the atlanto-axial area.

Traumatic dislocation of the atlas on the axis, when complicated by absence of the dens epistrophei, presents a problem of prevention of subsequent cord injury, because of the resulting marked instability of the neural arch. Such dislocations may reasonably be in any direction; it was posterior in this case. Posterior dislocations of the atlas on the axis should not result in as marked narrowing of the neural canal as is produced in anterior subluxation or dislocations, when these are due to relaxation or rupture of the transverse-atlantal ligament, resulting from those conditions of spontaneous or traumatic pathology directly concerned with the transverse-atlantal ligament alone. However, it is to be expected that recurrent dislocation would produce severe local irritation, and cause permanent damage to the cord and its coverings.

The dislocation may be reduced by continuous cervical traction or manipulation, but reduction of the dislocation appears insufficient, unless fixation of the atlas is made to the axis to prevent recurrent slipping. Varied methods of fixation have been used,—fascial suture, as advocated by Mixter and Osgood; wire suturing, as reported by Willard and Nicholson; and bone-grafting, such as was done in this case.

Because of the absence of the odontoid process in this patient, a fusion was desirable, and was obtained by using a short section of rib, split longitudinally and sutured to the first and second cervical vertebrae. The second cervical vertebra presents an ideal base for a bone graft, because of the bifid posterior spinous process which, when denuded of periosteum and drilled, offers a firm anchor for the bone graft. The first cervical vertebra, on the contrary, presents a very difficult area for fusion, because of the narrow, thin, bony ring which presents itself posteriorly.

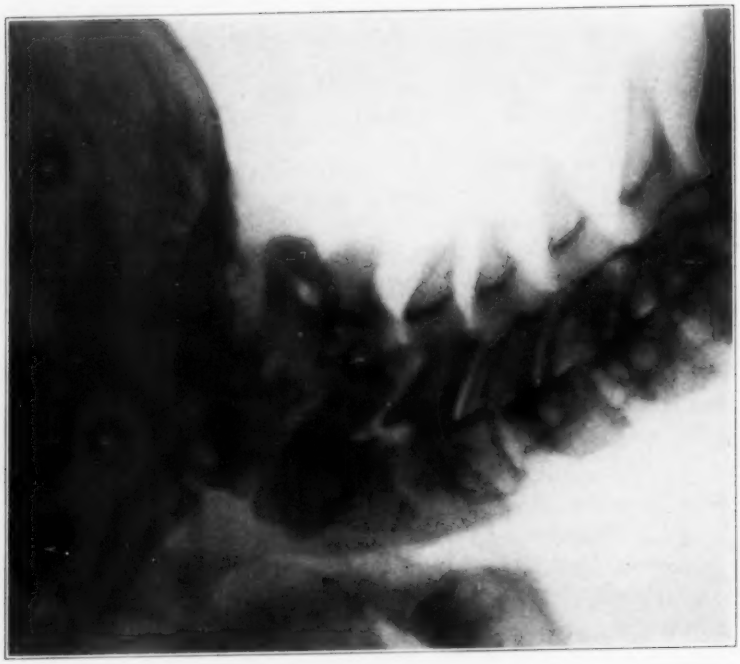

FIG. 2

Posterior dislocation of the atlas with rotation.

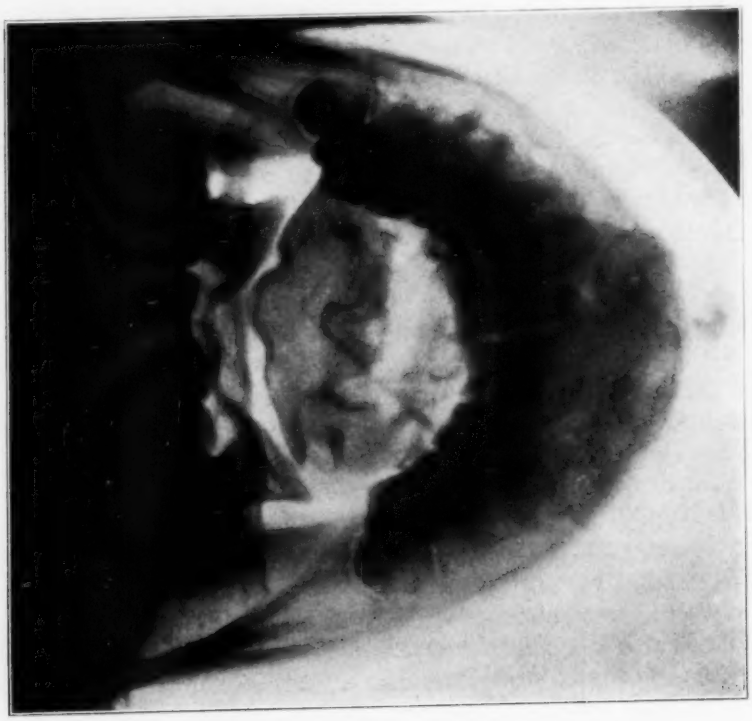

FIG. 1

Lateral dislocation of the atlas, showing absence of the dens of the axis.

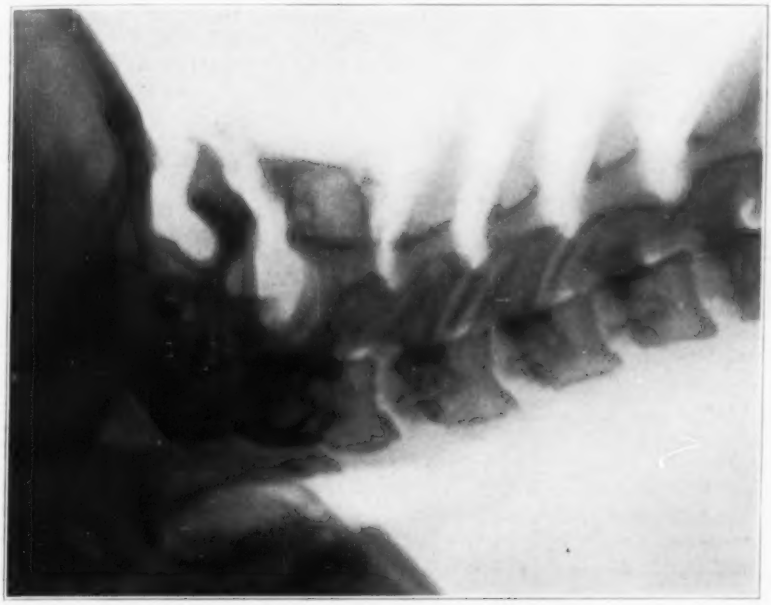

FIG. 4

Normal alignment of the axis and atlas, showing fusion by rib grafts.

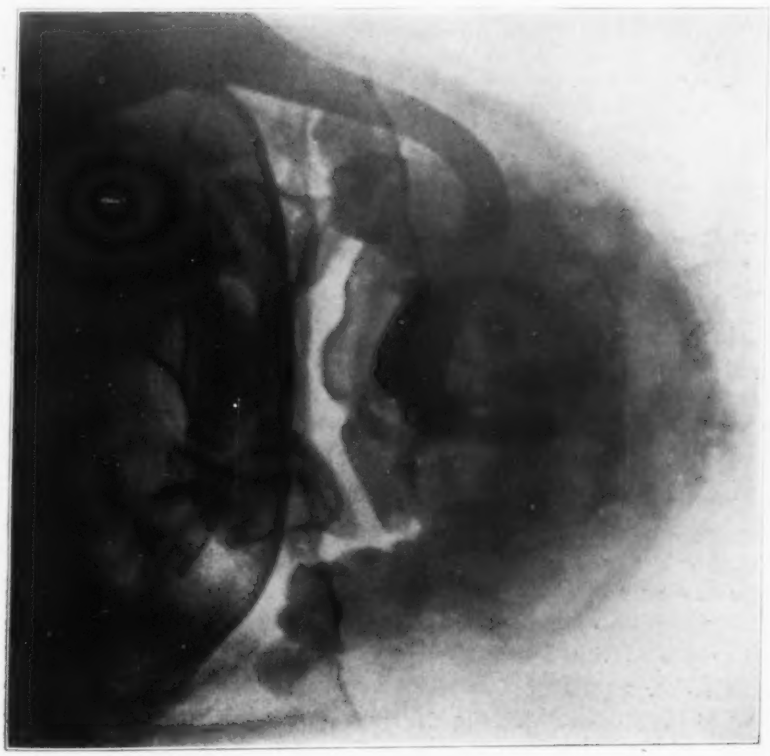

FIG. 3

Reduction of the dislocation following manipulation.

CASE REPORT

A white girl, aged fourteen, was admitted to the Ohio Valley General Hospital, Wheeling, West Virginia, on March 1, 1939, complaining of pain and stiffness of the neck and inability to straighten the head which was turned to the left side. One week before admission she had fallen while running, and a playmate had fallen on top of her, striking her head and neck forcibly to the ground. Her head was turned to the left side, and she was unable to move her neck. Physical examination was not remarkable, except for the head and neck. The neck was held stiffly in extension, the top of the head was tilted toward the left side, the face was rotated toward the left side, and the chin was tilted upward and away from the neck. Attempted motion in any direction was accompanied by marked muscle spasm and complaint of pain on the left side of the back of the neck near the base of the skull. Attempted motion in rotation to the right was prevented by bone block. Roentgenograms of the cervical spine, made anteriorly through the open mouth, showed lateral displacement of the atlas eight millimeters to the left (Fig. 1), and a lateral view showed a displacement of the atlas five millimeters posterior to the normal alignment with the axis (Fig. 2). There was complete absence of the odontoid process of the axis; just a small eminence appeared at the usual site of the dens epistrophei. Treatment was instituted at once by using cervical traction for one week. Reduction was not obtained; so, under cyclopropane anaesthesia, the head and neck were manipulated, and a reduction was secured which was accompanied by a definite "click". Reduction was verified by roentgenograms (Fig. 3), and a plaster cast was applied, incorporating the head, neck, and body. The girl was discharged from the Hospital on March 14, 1939, wearing the cast.

In view of the possibilities of recurrence of the deformity and resultant cord damage, an operation to fuse the atlas to the axis was advised and accepted by the parents.

On June 14, 1939, operative fusion was performed on the atlanto-axial area through a window in the back of the cast, cyclopropane anaesthesia was used. A linear incision was made from the base of the skull to the level of the posterior spinous process of the third cervical. The posterior spinous processes of the first and second cervical vertebrae were exposed subperiosteally. An autogenous rib graft was split longitudinally, and each of the resulting two grafts was sutured into position as follows: The lower portions of the grafts were drilled and placed on either side of the bifid posterior spinous process of the second cervical vertebra; black silk sutures were used to anchor the grafts. The upper ends of the grafts were likewise sutured to the denuded posterior arch of the atlas (Fig. 5). The soft parts were closed in layers. The posterior window of the cast was reapplied and secured by plaster bandages. The postoperative course was uneventful, and the girl was discharged from the Hospital on June 25, 1939, wearing the plaster cast. The cast was worn until September 1939 when a leather head and neck support was substituted. The leather collar was worn until May 1940, when roentgenograms (Fig. 4) showed satisfactory bony union; no support has been used since that time.

All motion of the cervical spine has returned to normal limits except rotary movement of the extreme upper portion, which is reduced about 50 per cent. of normal; it is assumed that this rotary motion occurs between the opposing articular facets of the skull and the atlas.

COMMENT

Ordinarily, in cases of anterior subluxation, complete reduction usually follows continuous cervical traction in bed. Reduction was not accomplished in this case of posterior dislocation until the patient was subjected to manipulation under general anaesthesia.

Upon initial examination, the position of the head and neck was an unusual one for an ordinary subluxation of the atlas without fracture of the odontoid process. The usual position is for the head to be held in

FIG. 5
Diagram of placement of rib grafts.

flexion, chin close to the neck, top of the head tilted toward and the chin rotated away from the side on which the atlas has moved forward. In this case of posterior dislocation, the neck was held in extension, chin was tilted upward and away from the neck, top of the head was tilted toward and the face rotated toward the side on which the atlas had moved backward.

SUMMARY

Dislocation of the atlas on the axis, complicated by congenital absence of the odontoid process of the axis, should be treated by reduction and operative fusion of these two cervical vertebrae, in order to prevent cord damage which would result from recurrent dislocation.

Since completing this report, another case of complete absence of the odontoid process of the axis has come to the attention of the author; treatment was begun on September 15, 1941. The patient is a white girl, aged twelve, with history of recurrent dislocation since the age of two; operative fusion is planned after temporary fixation in a plaster cast.

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THE TREATMENT OF DISLOCATION OF THE ACROMIO-CLAVICULAR JOINT BY OPEN REDUCTION AND THREADED-WIRE FIXATION

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Complete dislocation of the outer end of the clavicle has generally been regarded as a difficult lesion to reduce and fix until satisfactory repair has occurred. Treatment by closed reduction and fixation by external appliances has frequently left the joint in partial or complete dislocation. Hart has recently reported a method of external fixation with which he obtained good results. A plaster-of-Paris shoulder spica is applied while the scapula is elevated with the arm in a position of about 45 degrees of abduction. This anchors the elevated acromion. A layer of felt and a firm rubber sponge are placed over the lateral portion of the clavicle, which is then held down by two two-inch webbing straps with buckles which are incorporated within the plaster spica during its application. A period of six weeks to two months of immobilization is required for healing.

Treatment by open reduction and fixation of the fragment ends with sutures of wire or silk, or repair of the torn acromioclavicular ligament by means of silk or fascial strips has resulted in persistence of the dislocation

FIG. 1

Roentgenogram taken immediately after injury, showing the acromioclavicular dislocation.

in a large percentage of the cases. Because of the harmlessness of defects of the clavicle, Gurd, after experience with three cases, has recently recommended excision of the outer end of that bone in both early and late cases of acromioclavicular dislocation. Mumford has also recommended this procedure for old dislocations, based on an experience with four cases.

FIG. 2

Two months after the insertion of the threaded wires.

FIG. 3

Appearance five months after the operation and three months after the removal of the wires.

Open reduction and fixation of the acromioclavicular joint by means of two wires inserted from the side, through the acromion, across the joint, and into the clavicle have been employed by the author in two cases of recent dislocation. The technique of the operation is as follows: Under gas-oxygen anaesthesia a coronal incision is made over the outer one inch of the clavicle, and extended laterally over the acromion process and the attachment of the deltoid muscle to its outer side. The acromioclavicular dislocation is then reduced, and the clavicle is held in place by pressure with a chisel, while two fairly heavy threaded-steel wires are inserted with a hand drill from the side, through the acromion, across the joint, and into the end of the clavicle to a depth of about one inch. Each wire is cut off about one centimeter lateral to the acromion, leaving sufficient length for grasping with the chuck after healing is complete and the time for removal arrives. The superior capsule of the joint is then sutured as accurately as possible, and the incision of the skin and subcutaneous tissue is closed. The arm is held in a Velpeau bandage for one month, after which the upper arm only is fixed to the chest, while the forearm and hand are allowed to be free. At the end of two months the wires are removed and, after healing of the wound, the patient is allowed free use of the limb. Shoulder motion is not permitted while the wires are in place, because of the danger of breaking them.

One patient was operated upon four years ago and the other five months ago. In both cases the reduction has been maintained and there has been compete restoration of function.

The results are illustrated by the roentgenograms of the twenty-three-year-old male patient operated upon five months ago. Figure 1 reveals the dislocation on the day of injury. Figure 2 shows the wires in place shortly before their removal two months later. Figure 3 is the appearance five months after injury, and three months after removal of the wires.

Murray has used unthreaded Kirschner wires which are allowed to protrude through the skin and are removed after healing is complete. Theoretically this is a less desirable procedure, because of the greater likelihood of infection and of migration of the wire. The operation here described is simple and leaves the bones intact, which is a factor of some importance in the settlement of compensation cases. It is deserving of a trial in old as well as recent acromioclavicular dislocations.

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THE TREATMENT OF COXITIS

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The purpose of this article is to record what appears to the writer to be a definite advance in the general management of some types of coxitis. The regimen advocated is believed to be especially suitable for tuberculous coxitis and for other inflammatory lesions of the hip joint which run a similar course.

In coxitis, where there are roentgenographic findings of disease either in the acetabulum or in the head of the femur, or in both, the writer takes the view that the tendency to aim at ankylosis is quite wrong. He believes that both the synovial type and the chondro-osseous type can be so treated that good function, or at least partial function, can be obtained, and that the return of function to a joint is in itself preventive of recurrence. The author's experience suggests that encasing a tuberculous hip in a plaster-of-Paris spica is an undesirable method of treatment, often resulting in poor position and, worse, in a marked atrophy of muscles, decalcification of bone, and failure to arrest the disease. The writer confirms Seddon's opinion that simple traction in the acute stage, without a rigid splint, is eminently satisfactory.

These views are founded on experience and observations of cases treated during the years 1930 to 1940. All the patients referred to in the case notes were accepted as tuberculous by the Hull City Tuberculosis Department, and the majority were sent into the hospital from the Department's clinics. During the period reviewed, about thirty beds in the town hospital were set aside by the Health authorities for bone and joint tuberculosis, at least half being allocated for adult patients. When possible, children were sent to sanatoria in the country.

The writer, years ago, was much impressed by Rollier's work, and, while in a hospital in another industrial town, during a short period of two and one-half years, obtained unexpectedly good results by following his methods. Later these methods were again applied by the writer, but in more adverse circumstances, so that instead of being cared for in the Alpine solaria, situated at a high altitude amid snow-clad slopes, sheltered by pine forests in a dry, bracing atmosphere with pure air and strong sunlight, the patients were treated in huts in a back yard and in ground-floor wards of an old general hospital, situated almost below sea level in the center of Hull, a large seaport and industrial town, with a generally cold, moist, soot-laden atmosphere, and with artificial sunlight produced by mercury-vapor lamps. The fact that comparatively good results have been obtained under these definitely adverse circumstances, coupled with

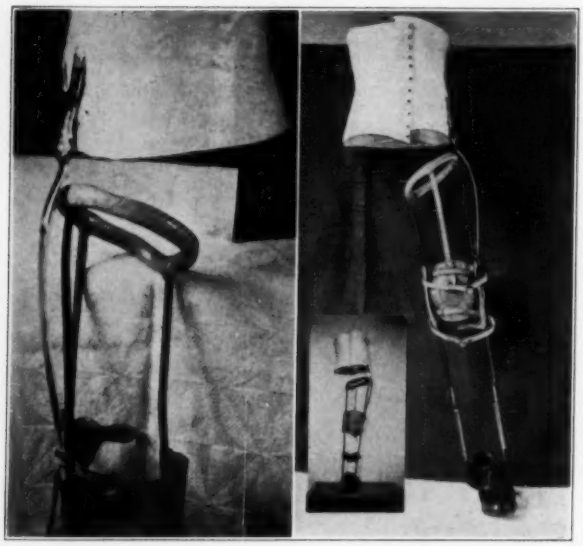

FIG. 1-A FIG. 1-B

Fig. 1-A: Illustrating the construction of the appliance and showing the plate and carriage type of spring attachment.

Fig. 1-B: Anteroposterior view of appliance, showing the abduction position. The inset shows spring incorrectly set.

the fact that many patients were adults in whom, according to most writers, the disease is more difficult to treat, prompted the preparation of this article. Gradually a suitable technique was evolved which was more applicable to the less favorable conditions, and the main points will later be described.

It should be mentioned that in the cases treated, the lesions were believed by the writer and his colleagues to be tuberculous, but, owing to the very nature of the methods, it was impossible to prove the infection by biopsy or culture, and, further, most of the patients with sinuses were admitted after the primary abscess had burst, and culture of the pus was unsatisfactory. Incision was used only when secondary infection had occurred. Tubercle bacilli were often recovered from aspirated abscesses, but it was found that hip lesions usually did not produce abscesses suitable for aspiration. Spine lesions, on the other hand, gave repeated material for this purpose.

The writer does not advocate these methods for diseases such as rheumatoid arthritis, osteo-arthritis, or staphylococcal osteomyelitis. His experience has been that they give good results in tuberculous disease and in lesions of obscure etiology which run a similar course and which sometimes follow streptococcal infections of other organs.

The general principle of these methods might be stated to be prolonged rest, with relative but not absolute immobilization of the affected joint. In other words, they consist in: rest and immobilization during the acute stage; rest with minor movements after pain has disappeared; and rest with voluntary movement in the convalescent stage, coupled with free movement of all parts of the body not affected, and maintenance of the fullest possible general health and vigor.

DETAILS OF TREATMENT

In cases of the synovial type without roentgenographic evidence of the disease, simple extension by weight and pulley is used. No attempt is

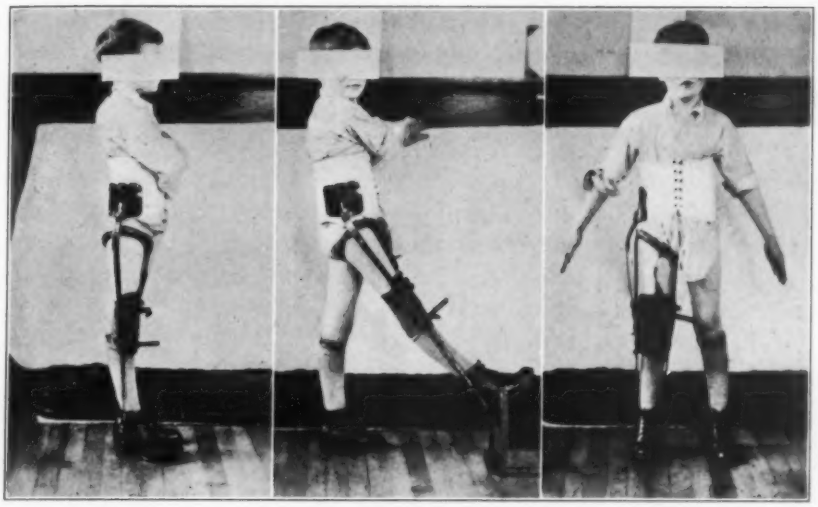

FIG. 1-C FIG. 1-D FIG. 1-E

Patient in Case 5 wearing abduction caliper.

made to obtain abduction, as this is considered unnecessary and undesirable. A permanent cure with full function is to be expected, provided the patient is able and willing to carry out advice, staying the necessary time in the hospital—usually from a year to eighteen months—and afterwards living a healthy life.

Patients showing or later developing irregularity or erosion of the acetabulum or of the femoral head, or of both, require greater care, and full function will probably not be obtained. Nevertheless, even when the disease is extensive with total destruction of the joint, a new joint with limited function may be formed in time, and will be of great value, especially in walking. Such patients may suffer from some shortening of the limb, particularly when the disease has occurred in childhood.

As soon as irregularity or erosion is realized, the limb is placed on a wheeled traction carriage, so that prolonged strong traction may be made on the joint, without using weights so heavy that adhesive applications will damage the skin. The wheeled carriage is overhead, and the supporting frame keeps the bedclothes from interfering with the motion. This apparatus has the advantage that it can be made by any hospital carpenter from material which he always has in stock,—namely, wood and curtain fittings. The limb is supported in a plaster-of-Paris trough, suspended from the track by brass side pieces or later, when the joint is painless, by flexible suspension from the overhead track.

The treatment is continued much longer than is usually advised, but the weight may be somewhat reduced after the painful stage is passed. Traction is continued for from eighteen months to two years, and is not removed until roentgenograms, taken at six-month intervals, show no further spread of the disease, and exhibit commencing sclerosis and

clarification of the joint space. This latter state, coupled with the general well-being of the patient, increase in weight, and only small or minor atrophy of the muscles as compared with the sound side, is the indication for the next or convalescent stage of the treatment.

The patient is allowed to get up and to use the joint gently without weight-bearing. For some years this proved a great practical difficulty, and the usual adduction deformity was a constant source of disappointment. About 1934, the writer devised a special walking caliper by means of which the tendency to adduction deformity was prevented, and yet a good range of flexion and extension was possible.

The appliance consists of a Thomas type of walking caliper, fitted to a pelvic belt of durable, washable, non-inflammable celluloid material, carefully made from a plaster mold of the patient. Attached to this belt is a metal plate with an arm and joint similar to that used in some artificial limbs for above-knee amputations. Extending downward from the joint to the outer rod of the caliper in the region of the knee is a flat spring of one or two leaves, similar in principle to that in the ordinary carriage spring. This exerts an abducting force of from three to ten pounds, according to the needs of the patient, and at the same time rigidly controls rotation. The joint above the spring is centered over the hip joint, and allows free flexion and extension. The lower end of the spring is adjustable to permit correct positioning of the caliper ring, which, of course, must fit accurately. The pelvic belt must be fairly deep to take the lateral thrust.

The appliance has been improved in detail, and the present model is depicted in Figures 1-A through 1-E. It is original so far as the writer is concerned. Jordan's excellent treatise does not show any movable brace using this abduction principle, but the spring could be applied to a Hessing brace with slight modification. (A recent modification of the apparatus allows the lower attachment of the spring to move up and down in a couple of thimbles or slots, instead of being fixed with screws to the caliper. This change facilitates fitting and permits abduction and adduction, as well as flexion and extension.)

The writer believes the appliance to be of great value: it allows the patient to redevelop the hip-joint muscles during the period in which the new joint surfaces are being formed, and the healthy muscles in turn react to increase the range and mobility of the joint. Without it, the overaction of the powerful adductor group of muscles produces deformity and loss of function, starting a vicious circle which leads to greater deformity and ends in a useless fibrous ankylosis in bad position, rendering proper walking impossible.

In the beginning, the apparatus is worn continuously, even during sleep. After the new joint surfaces have been reformed (in severe cases new joints may actually appear), or when healthy muscles have developed all around the joint, the appliance can be safely removed, and weight-bearing may be permitted. It is better to remove the appliance gradually,—

at first during the night, then in the house, later for short walks, etc., until full walking outdoors can be carried out without strain or fatigue.

Here it is wise to stress that the apparatus must fit well and must prevent weight-bearing. The writer had a failure in one patient who had a relapse, owing to slipping of the caliper adjustment and failure of the patient to report the trouble. If the joint of the girdle is not accurately centered over the hip joint, broken springs and serious wear at the junction will occur. A good deal of trouble was at first experienced in getting the right type of spring steel and temper, but this has now been overcome.

From the beginning of treatment right through to the convalescent period, and sometimes after return to work, the patients have received regular irradiation by mercury-vapor lamps or by natural sunshine. Cod-liver oil has been continuously administered, and a high-vitamin diet, containing plenty of fresh raw vegetables and fruit, has been used. Protein has been supplied in the form of eggs, fish (mostly cod and herring), and smaller quantities of bacon and beef.

In spite of the prolonged recumbency, there have been no cases in which renal calculi have developed, and the bones have shown roentgenographically increasing calcification after the active stage of the disease has passed. The increase of calcification has occurred more rapidly during the stage of convalescence and return of function.

The writer believes that these general measures play a most important part, and that the constant use of irradiation and cod-liver oil accounts for the absence of renal calculi and the increased calcification of the bones, which, in turn, plays a large part in the healing process.

STATISTICAL NOTE

During the period under review, a total of thirty-nine cases of tuberculous coxitis were admitted to the wards. Excluding the fourteen cases which are reported in detail in the following pages, they fall into four groups:

Group		*No. of Patients*
I.	Patients treated before the present methods were fully elaborated (from 1930–1933)	5
	All of these are well, but several have fibrous or bony ankylosis.	
II.	Patients who discharged themselves against advice	10
	Died	2
	Alive and well	4
	Untraced or condition unknown	4
III.	Patients discharged for other causes	7
	Transferred to other hospitals on account of local, financial, or administrative reasons	6
	Sent home	1
	This small child lost the whole of the head and neck of the femur by absorption. A reconstruction operation may be possible later. At present she walks with a caliper.	
IV.	Patients at present under treatment	3
	All are progressing favorably and several should have a good functional result. One has full function and arrest of hip disease, but a spine lesion has developed.	

CASE REPORTS

CASE 1. A male, aged thirteen years, was admitted on August 29, 1933 with a history of intermittent pain in the right hip of eight months' duration. The patient complained of severe pain in the right hip with limitation of movement.

Roentgenographic examination on September 2, 1933 showed the pelvis and hip joints to be normal. Treatment consisted of simple extension. Physical examination on October 23, 1933 disclosed limitation of abduction. Flexion and extension were almost normal. Further roentgenograms, taken on November 4, 1933, apart from disease atrophy, showed no evidence of disease, and clinical examination, three days later, revealed freedom of all movements. The patient was discharged well on April 18, 1934.

FIG. 2-A

Case 2. June 28, 1935. Tuberculous or possibly pyogenic destruction and disorganization of right hip joint.

FIG. 2-B

Case 2. November 10, 1938. Remarkable regeneration of head of femur.

In January 1940 a letter from the father stated that the patient was serving in His Majesty's Army in Palestine.

CASE 2. A male, six years of age, was admitted on June 25, 1935 with adduction and slight eversion and flexion of the right hip. There was apparent ankylosis. The patient had had diphtheria during March and April 1934, followed by otitis media. Before this condition cleared up, pain and an abscess in the region of the right hip had developed. The patient had been treated at other hospitals with plaster of Paris and a walking caliper.

Roentgenographic examination on June 28, 1935 (Fig. 2-A) showed tuberculous or possibly pyogenic destruction and disorganization of the right hip joint. Treatment consisted of extension, and in March 1936 an early model of the abduction caliper was applied. The tuberculin Mantoux test on April 14, 1936, was negative, and the patient was discharged on May 4, 1936. Follow-up examination on December 8, 1936 showed the presence of an adduction deformity, and the patient was treated as an out-patient. The deformity gradually disappeared during 1937, and treatment was concluded at the end of the year. Roentgenographic examination on November 10, 1938 (Fig. 2-B) showed marked improvement; the right hip joint was almost normal. There was full function, and movement was free.

In January 1940 the mother reported that the child was quite normal.

CASE 3. A male, ten years of age, was admitted on November 20, 1935, complaining of difficulty in walking, with pain in the right hip of fifteen months' duration. Physical examination showed wasting of the gluteal muscles and total limitation of movement in the right hip.

Treatment consisted of simple extension. Roentgenographic examination on January 9, 1936 showed no bone changes in either hip. Later roentgenograms, however, on February 9, 1937 revealed destructive changes in the acetabulum of the right hip with irregularity of the joint surface. The appearance was that of tuberculous disease. Clinical examination on March 7, 1937 showed a full range of movement; so an abduction caliper was not required. The patient was discharged on June 2, 1937, and treatment was concluded in the autumn of 1937.

On January 29, 1940 full movement was present, and the patient's general health was very good. Follow-up roentgenograms on February 2, 1940 showed smooth and normal contour of the articular surface of the acetabulum.

CASE 4. A male, twenty-four years of age, was admitted on August 28, 1935 with a discharging sinus over the anterior aspect of the right hip. A fair degree of movement was present. He was also suffering from otitis media, probably tuberculous. He stated that the disease had started in 1927 and he had been treated in other hospitals in 1928, 1929, and 1931.

Roentgenographic examination on August 30, 1935 showed tuberculous erosion of the right acetabulum. An abduction frame was used, and on March 11, 1936 the roentgenographic appearance of the hip suggested complete inactivity of the disease. In April 1937 an abduction caliper was fitted, and the patient was discharged on May 8, 1937. Treatment was concluded in September 1938. Roentgenograms, taken on September 9, 1938, showed sclerosis to be taking place.

In January 1940 the sinus had healed, there was almost complete return of function, and the patient was working as an attendant in a parking lot.

CASE 5. A male, aged seven years, was admitted on July 13, 1936, complaining of pain and limping of nine months' duration. Examination revealed wasting of the right thigh, limitation of all movements, and marked pain.

Roentgenographic examination on July 14, 1936 disclosed advanced and active tuberculosis of the right hip joint. Treatment consisted of simple extension, and roentgenograms on October 22, 1936 showed definite sclerosis of the femoral head and acetabulum. On April 7, 1937 clinical examination showed a discharging sinus in the region of the right hip. Adduction and limitation of movement were noted. In October 1937

FIG. 3-A FIG. 3-B

Fig. 3-A: Case 6. September 20, 1936. Apparent osteo-arthritic changes involving left hip joint.
Fig. 3-B: Case 6. June 6, 1939. New bone formation with sclerosis.

an abduction caliper was fitted (Figs. 1-C, 1-D, and 1-E). Improvement was gradual, and the patient was discharged on December 23, 1937. Roentgenographic examination on June 6, 1939 showed improvement in sclerosis; treatment was concluded in the summer of that year. After eighteen months of use, the caliper was discarded.

In January 1940 the patient was in good health, with a free range of movement, but there was some permanent shortening, due to interference with growth of bone.

CASE 6. A female, twenty-one years old, was admitted on June 22, 1936 with a history of intermittent pain and increasing stiffness of the left hip of three months' duration. The left hip was slightly flexed and fixed. Treatment consisted of extension on an overhead runner. Roentgenographic examination on September 20, 1936 (Fig. 3-A) revealed what appeared to be osteo-arthritic changes involving the left hip joint. In June 1937 an abduction caliper was fitted. There was very little movement in the joint, and the patient was discharged on June 25, 1937. Roentgenograms, taken on July 26, 1937, showed the same condition as before. Treatment was concluded in August 1938. Follow-up roentgenograms on June 6, 1939 (Fig. 3-B) disclosed new bone formation with sclerosis.

When last seen in January 1940, the patient was in good health and was able to walk perfectly. No abnormality of carriage could be detected, although there was limitations of motion in the joint.

The tuberculous origin in this case might be disputed; it might have been a chronic pyogenic infection.

CASE 7. A male, aged twenty-one years, was admitted on February 14, 1935 with a history of limping and pain in the right hip of two months' duration. The right hip was very painful, and there was no movement.

Roentgenographic examination on February 19, 1935 revealed arthritic destruction of the right hip joint. The Wassermann reaction was negative. Treatment consisted of an abduction frame with roller extension. Further roentgenograms on September 8, 1935 showed tuberculous disorganization of the right hip joint; on January 21, 1936 examination showed that the condition had advanced; and on April 30, 1937 there was improvement. On June 9, 1937 an abduction caliper was fitted, and the patient was discharged on July 30, 1937. Treatment was concluded in September 1938. This had been a very severe infection, resulting in complete loss of the femoral head.

In January 1940 the patient was in good health and working as an attendant in a parking lot. Some adduction deformity was present. Roentgenograms, taken on February 2, 1940, showed some regeneration of bone.

CASE 8. A male, fifty-five years of age, was admitted on November 22, 1934 with limitation of movement in the left hip. Scars from an old operation were noted, and there was a discharging abscess in the left groin. The Wassermann reaction was negative. The patient stated that thirty years previously he had suffered with tuberculosis of the left hip. Later several operations had been performed, and nine years prior to admission abscesses in the left groin had appeared. Three weeks before admission pain with abscess and sinus formation had developed in the left hip.

Roentgenographic examination on November 27, 1934 disclosed old tuberculous disorganization of the left hip joint with complete absence of the femoral head and acetabulum. Treatment consisted of an abduction frame. On December 2, 1935 the patient was fitted with an abduction caliper, which he wore for eighteen months, owing to a persistent tendency to adduction deformity. The patient was discharged on December 23, 1935. The sinus healed, and treatment was concluded in September 1937.

In January 1940 the patient was in good health. Only a small range of movement was obtained, but the adduction deformity was relieved, enabling him to walk quite nicely. When seen in September 1941, the patient was in good health. Roentgenographic

FIG. 4-A

Case 9. October 10, 1934. Old tuberculous destruction of left hip with abscess formation.

FIG. 4-B

Case 9. July 10, 1938. Increased sclerosis and false interjoint space.

examination on October 10, 1941 revealed the appearance of the hip joint to be almost identical with that shown by the roentgenogram taken in 1935.

CASE 9. A female, eleven years of age, was admitted on October 2, 1934. Physical examination showed a scar on the outer aspect of the left hip, marked limitation of abduction, and other movements about one-half normal. She had fallen at the age of two years and had had trouble in the left hip thereafter. She had been treated in three other hospitals.

Roentgenographic examination on October 10, 1934 (Fig. 4-A) revealed old tuberculous destruction of the left hip with abscess formation. On October 18, 1934 the abscess in the left hip was aspirated, and an abduction frame with roller extension was applied. An experimental abduction caliper was fitted on August 29, 1935; this was worn for twelve months. The patient was discharged on December 24, 1935, and treatment was concluded in September 1936.

Follow-up roentgenograms on July 10, 1938 (Fig. 4-B) showed increased sclerosis and a false interjoint space. When last seen on August 4, 1938, the patient was in good health, and movement was practically normal.

This is an interesting example of new joint formation and return of function.

CASE 10. A female, thirty-two years of age, was admitted on September 22, 1936 with a history of pain and stiffness in the left hip of eight months' duration, which had become so severe that walking was prevented. On admission there was almost no movement in the left hip, and the patient complained of pain.

Roentgenographic examination on September 25, 1936 (Fig. 5-A) revealed marked tuberculous disorganization and destruction of the femoral head and acetabulum. Treatment consisted of extension with an overhead runner. Roentgenograms, taken on April

FIG. 5-A

Case 10. September 25, 1936. Marked tuberculous disorganization and destruction of femoral head and acetabulum.

FIG. 5-B

Case 10. February 4, 1940. Arrest of disease and complete bony ankylosis in good position.

28, 1937, showed increased calcification and improvement of the condition. An abduction caliper was fitted on February 2, 1938, and the patient was discharged on May 7 1938. Treatment was concluded in April 1939.

When last seen, on February 4, 1940, the patient's general health was very good, and she was working normal hours in a shop. Roentgenographic examination at this time (Fig. 5-B) showed arrest of the disease and complete bony ankylosis in good position.

CASE 11. A female, aged twenty-one years, was admitted on June 28, 1937, complaining of pain in the back, stiffness of the left hip, and weakness dating from February 1937. She had worked until May 1937. Physical examination showed scoliosis and kyphosis. The patient coughed and stated that she felt run down.

Roentgenographic examination on July 2, 1937 revealed tuberculous involvement of the third lumbar vertebra. The patient was placed in a plaster stretcher bed, and overhead runner extension was later added. In August 1937 she complained of pain in the left hip, and roentgenographic examination on August 8, 1937 disclosed tuberculous involvement of the upper zones of both lungs, although the appearance of the hip joints was normal. However, further roentgenograms on January 21, 1938 showed tuberculous involvement of the left hip joint. Due to the war, the patient was prematurely discharged on September 3, 1939 and, at her home without surgical supervision, was fitted with an abduction caliper attached to a spinal jacket. The spring was incorrectly set (Fig. 1-B, inset), but this error was partly rectified in January 1940. At this time the patient's general health was good, but an adduction deformity was present. In April 1940 this deformity was still present, and the spring was given greater action. Examination in June 1940 showed that the deformity had persisted, and fibrous adhesions had formed. On August 2, 1940, during a ten-days' stay in the hospital, the adhesions were broken down under anaesthesia, and the adduction deformity was corrected. On

FIG. 6-A

Case 12. March 6, 1937. Tuberculous erosion of right femoral head.

September 6, 1940 the patient's general health was good, the adduction deformity was corrected, and she walked slowly with the abduction caliper and the help of canes.

When last seen, at the end of October 1941, the patient was walking about quite nicely with no adduction deformity, but there was very little, if any, movement in the joint. Her general health was quite satisfactory.

This case shows how methods can be used for combined spine and hip tuberculosis and illustrates the need for surgical supervision of fitting of the abduction caliper.

CASE 12. A male, fourteen years old, was admitted on March 5, 1937 with a history of pain in the right hip of nine months' duration, which had been worse during the past two months. On admission, all movements were limited and painful, and there was functional ankylosis.

Roentgenographic examination on March 6, 1937 (Fig. 6-A) revealed tuberculous erosion of the right femoral head. Treatment consisted of extension with overhead runners, with the hip in a position of some abduction and flexion. On October 14, 1937, the patient was fitted with an abduction caliper, and roentgenograms on November 17, 1937 showed some improvement in the condition. Pain was absent for five months, and the patient's general condition was very good. On April 14, 1938 the patient was discharged, wearing the abduction caliper and walking nicely with a good range of movement. He was readmitted on November 8, 1938, complaining of pain when walking, and looking ill. All movements of the right hip were limited, the hip was flexed, and there was wasting of the muscles. The patient had lost weight. He stated that the caliper adjustment had given way and the spring had broken. He had not reported it and had continued to walk with the useless caliper, bearing full weight on the hip joint.

FIG. 6-B

Case 12. July 8, 1940. Condition has not advanced, and there is a tendency to sclerosis.

Roentgenographic examination on November 19, 1938 showed marked erosion and destruction of the femoral head and acetabulum. Treatment consisted of extension as before. On March 15, 1939 an abscess on the lateral aspect of the thigh was aspirated, and pus was obtained. No organisms were grown on culture, and no tubercle bacilli were found in smears. The patient's general condition was poor, but it improved during the summer of 1939 and the winter of 1940. The lost weight was regained by spring. The patient was refitted with an abduction caliper, and on July 8, 1940 roentgenographic examination (Fig. 6-B) showed that the condition had not advanced and there was a tendency to sclerosis. In August 1940 the patient was up, wearing the abduction caliper, and was in good health. There was slight movement in the joint.

When last seen, in October 1941, the patient's general health was very good, and he walked quickly. Movement in the hip joint was relatively good: motion in flexion, 25 per cent.; full extension; 5 per cent. of rotation; little abduction or adduction. No adduction deformity was present. The patient was working short hours as a packer.

CASE 13. A male, aged nine years, was admitted on April 6, 1939 with the left limb fixed in a plaster-of-Paris spica. He had been in another hospital for twelve weeks and, before the spica was applied, there had been a slight flexion deformity and pain on movement.

On admission, the plaster spica was removed, the limb was placed on an overhead traction carriage, and continuous extension was applied. The patient was transferred to a country sanatorium in October 1939. Roentgenographic examination on November 20, 1939 showed slight irregularity of the acetabulum on the left side. In July 1940 the patient's condition was very satisfactory: 40 per cent. of motion in flexion and 10 per cent. of abduction were present; there was no flexion deformity; and the general condition was good. In August 1940 the extension was removed for periods, and slight movements in bed were encouraged. Roentgenographic examination on September 24, 1940 showed some deformity of the acetabulum. The appearance was that of a healed tuberculous acetabulum. In December 1940 the general condition was still very good. Seven-eighths of full range of abduction and 80 per cent. of flexion and extension were present. The patient was fitted with a plain walking caliper.

Roentgenographic examination on February 12, 1941 revealed irregular sclerosis of the acetabulum, and the appearance was that of a healed tuberculous lesion. The patient was walking about freely, and his general condition was very satisfactory.

FIG. 7-A

Case 14. August 5, 1938. Partial destruction of head of femur.

This was a case with only minor roentgenographic evidence of disease and is an example of almost complete restoration of function. It was unnecessary to use the

spring abduction caliper, since there was no tendency to adduction deformity, due to the presence of free movement.

CASE 14. A male, aged seventeen years, was admitted on December 10, 1937, with a history of pain in the right hip on walking, and a limp for the previous two months. Examination showed severe limitation of movement, wasting of the thigh muscles, kyphosis in the lower thoracic region, and limitation of flexion of the spine. The patient stated that he was losing weight, and he looked thin and pale.

Roentgenographic examination on December 17, 1937, showed active tuberculous involvement of the right hip and of the twelfth thoracic and first lumbar vertebral bodies. Treatment consisted of a plaster bed fitted to a stretcher, complete with overhead traction arrangement and a separate plaster trough splint to hold the right leg. The patient's progress was slow. Figure 7-A shows the condition of the hip on August 5, 1938. On October 4, 1938, a large abscess over the external aspect of the right thigh was aspirated. There was no record of films or of culture. Roentgenographic examination on June 16, 1939, showed good bone regeneration. Further examination on June 13, 1940 showed that ankylosis seemed to be forming between the affected vertebrae, and that a calcified psoas abscess was also present.

The patient's progress during 1939 showed a good deal of improvement, but he still seemed thin. During 1940 he steadily improved. In April it was noted that there was no adduction deformity, but some flexion and abduction movement was present. On May 24 he was fitted with the abduction caliper and allowed to get up a little during the day. The sinus, which had been inclined to discharge from time to time, started to run again, and in July the patient was ordered back to bed.

In April 1941 it was noted that the patient's condition had greatly improved, and

FIG. 7-B

Case 14. October 6, 1941. Partial reformation of head of femur with increase in density of the head and neck structure.

that the sinus rarely discharged. The sinus finally healed satisfactorily in May 1941, and the patient was allowed to get up and to walk with the appliance. During the spring and summer months he was sent away to a seaside hospital as a convalescent. The abduction spring was removed at the end of September, and the patient was then allowed to go about wearing the spinal jacket and walking with the caliper.

On October 6, 1941, the condition of the hip was as follows: good mobility (taking into consideration the extent of the disease) with a range of flexion of 25 degrees and full extension; abduction and adduction were unexpectedly free, allowing approximately 25 degrees. Figures 7-B and 7-C show the roentgenographic appearance of the hip and spine at this time.

FIG. 7-C

Case 14. October 6, 1941. Healing and calcification of old psoas abscess.

SUMMARY OF CASE REPORTS

Case 1 shows complete recovery in synovial type of the disease.

Cases 2, 3, 4, 5, 6, 12, 13, and 14 record complete arrest of disease with movable joints and return of function in patients suffering from definite chondro-osseous disease. They show all grades of the disease from mild to very serious types. Cases 2 and 6 might be regarded as nontuberculous; if so, they illustrate the value of the methods for pyogenic infections.

Cases 8, 9, and 14 demonstrate the formation of new or false joints with return of function and arrest of the disease.

Case 10 shows that the regimen does not prevent bony ankylosis if nature prefers that type of repair, but does ensure good position.

Cases 11 and 14 record the successful treatment of coxitis complicated by spine and lung lesions and spine disease, respectively.

SUMMARY

1. The practice of aiming at ankylosis and the use of plaster-of-Paris spicas in the treatment of chronic inflammatory lesions of

tuberculous or avirulent pyogenic infective origin in the hip joint are not approved.

2. Rollier's work and recommendations are confirmed and supported, and it is contended that similar results may be obtained in orthopaedic hospitals not so fortunately placed as the Alpine solaria by adopting methods like those outlined in the foregoing article.

3. It is believed that a walking caliper with an anti-adduction spring, as illustrated, may prove useful in the hands of other surgeons.

The writer wishes to express his appreciation to J. E. Bannen, M.B., F.F.R., D.M.R.E., for his aid in the preparation of the roentgenograms and his constant advice and helpful discussions on the roentgenographic appearances of the cases through the ten-year period of the observations.

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MARCH FRACTURE OF THE FEMUR

Report of a Case

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March fracture of the femur is uncommon. The only reference to this condition noted in the recent English literature was the report by Nordentoft, in 1940, who reported two cases in the distal femur and two in the tibia discovered in young men, aged nineteen to twenty-four, who had recently entered the military service. The fractures were attributed to "a continued rhythmic, unaccustomed strain". His cases resembled tumor, and Ewing's sarcoma was suspected. He emphasized the differential diagnosis, and recommended biopsy when necessary. This type of fracture is common in the metatarsals, especially in the second, and has been recognized since its description by Breithaupt of Germany in 1855. Since then many reports of march fracture of the metatarsals have appeared, especially in the foreign literature. Recent case reports and a

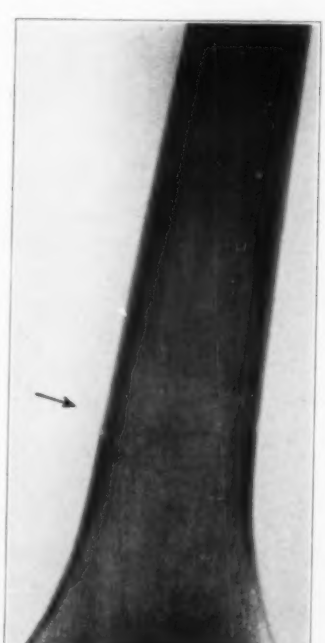

Fig. 1-A

Fig. 1-B

Left femur July 10, two days after onset of symptoms. Arrow indicates fracture line.

FIG. 2-A

FIG. 2-B

Left femur August 11, showing callus formation after thirty-two days. In lateral view note transverse lines above fracture site.

review of the literature have been furnished by Elward, and by Meyerding and Pollock. Characteristically the fracture is spontaneous, associated with pain on weight-bearing and local tenderness, and roentgenograms reveal a faint fracture line with subsequent periosteal reaction and callus formation. One or more light fissures may be noted from which callus subsequently develops. A diagnosis of sarcoma is not uncommon, and such a diagnosis was made early in this case. Straus described the pathology in a patient where the metatarsal was excised for neoplasm. If the diagnosis is not definite, biopsy may be necessary. With proper rest and support, the prognosis is uniformly good.

CASE REPORT

G. J., a white male, aged seventeen, was admitted to Walter Reed General Hospital August 2, 1941, by transfer from another military hospital. He entered the military service July 1, 1941, after many months of leisure. Eight days later, while engaged in calisthenic drill, he suddenly experienced sharp pain above the left knee, unrelated to direct or indirect trauma. Two hours later the pain became acute, and he walked with a marked limp and required hospitalization. Roentgenograms revealed a small crack in the cortex of the femur twelve centimeters above the joint, but this was not considered significant, since there was no trauma. After one week on crutches he was permitted to

walk unsupported for two more weeks. Roentgenograms then, three weeks after onset, revealed a "bony tumor", and physical examination showed that there was some tender tumefaction. A tentative diagnosis of osteogenic sarcoma was made, and he was admitted to this hospital.

Physical Examination: The patient was of the asthenic type, height 72 inches, weight 140 pounds; his blood pressure was systolic 122, diastolic 66 millimeters of mercury. His general physical examination was negative. There were no enlarged glands. On palpation of the left thigh, there was a firm, slightly tender mass, making an irregular ring around the lower femur. Muscle strength was normal, and knee motion was normal and painless. Pain was present only on weight-bearing. The Kahn test was negative, and blood and urine were normal. Blood chemistry analysis was:

Calcium 10.1 milligrams per 100 cubic centimeters
Phosphorus 2.4 milligrams per 100 cubic centimeters
Phosphatase 8.5 units (maximum normal 10 units).

Roentgenographic Findings: The report on the roentgenograms taken July 10, 1941 (Figs. 1-A and 1-B), and transferred to this hospital read, "The cortex of the left femur on its medial aspect about 12 cm. from the knee joint exhibits a very small bony defect which is interpreted as due to an incomplete fracture, practically only an infraction of cortex." Chest: "Except for calcified primary tuberculous lesions about each hilus, the chest is negative." The report on the roentgenogram taken on admission to this Hospital,

FIG. 3-A

FIG. 3-B

Roentgenograms taken on October 24, 1941, show firm bony union.

August 3, 1941, read, "About 12 cms. proximal to the left knee joint the left femur exhibits callus formation, moderate periosteal formation . . . the above findings interpreted as incomplete fracture. The bony repair process is quite orthodox and does not suggest malignancy". The report on the roentgenogram taken August 11, 1941 (Figs. 2-A and 2-B), read, "There has been further increase in callus deposition about the distal end of shaft of left femur".

After one week in bed, he was fitted with an ischial caliper for walking. On August 29, 1941, he was returned to his proper station to continue his training during further convalescence.

Roentgenograms taken on October 24 showed firm bony union.

SUMMARY

This case of spontaneous march fracture of the femur is unusual, and presents the question of the most common differential diagnosis,—sarcoma. In view of the course and roentgenographic findings, biopsy was not performed. With increased military training for previously inactive young men, additional cases may be encountered.

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AN ADJUSTABLE VOLAR-FLEXION SPLINT

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This splint was originally designed for a burn extension contracture of the fingers of the hand, but should be of value in extension contractures of any etiology. It is somewhat different from the usual splints constructed to obtain flexion, and the author believes that it is more efficacious.

It satisfies the requisites of a traction hand brace as outlined by Kanavel[1],—namely, ease of application by both patient and physiotherapist, and constant traction with the hand maintained in the dorsiflexed position during the period of immobilization. It consists essentially of a cock-up splint of which the distal end is tunnelled to receive rigid sliding finger supports (Fig. 1). The two main features of the brace are firm fixation and right-angle traction. The former is obtained by means of a wrist strap attached to the hand piece of the brace in a V-shaped manner, the apex of the V lying distally; and the latter, through the use of rigid sliding finger supports (Fig. 2). These support the phalanx proximal to the extended joint, while elastic traction is applied to the phalanx distal to the contracted interphalangeal joint. By this means, the line of pull is directed solely on the involved interphalangeal joint, and is not expended on the contiguous joint or joints. This form of right-angle traction also eliminates the main objection to the usual cock-up traction splint designed to obtain flexion of the interphalangeal joints,—namely, the tendency for such traction to pull the finger into a straight line, rather than bend it at its interphalangeal joints. As a result, there is generally little or no flexion obtained at the distal interphalangeal joint, while only incomplete flexion is possible at the proximal one. Again, the opportunity of such traction to bend the finger at its proximal interphalangeal joint would seem to vary inversely with the mobility of the corresponding metacarpal bone. Thus palmar traction on the fifth finger with the wrist in dorsiflexion results only in slight flexion of the proximal interphalangeal joint, while similar traction on the index finger will result in considerable flexion at the proximal interphalangeal joint. This observation corresponds with the anatomical fact of decreasing metacarpal mobility from the ulnar to the radial side of the hand. The additional use of the sliding phalangeal supports, by eliminating the factor of metacarpal mobility and fixing in extension the phalanx proximal to the contracted interphalangeal joint, permits traction to flex fully both the proximal and distal interphalangeal joints.

The construction of the brace is comparatively easy. The entire splint, with the exception of the U clamps, is constructed from 12-gauge duraluminum. It is lined with sponge rubber three-eighths of an inch

*Service of Samuel Kleinberg, M.D.

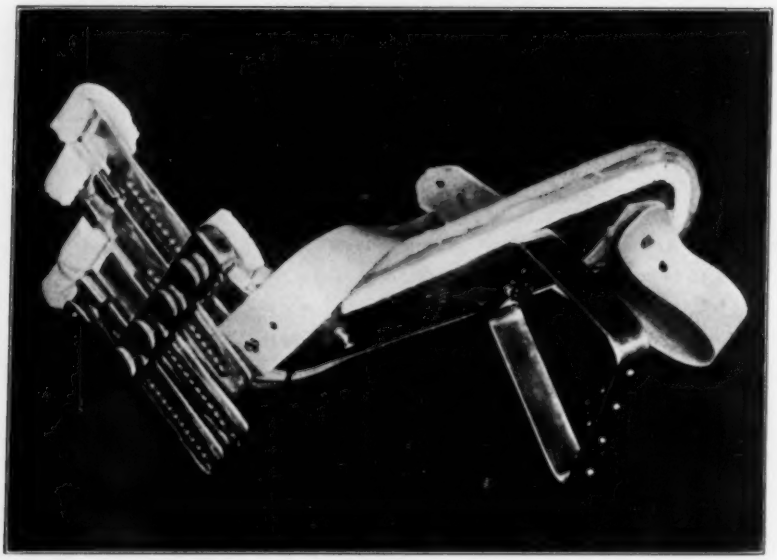

FIG. 1

Oblique view showing tunnelled cock-up splint, with rigid sliding finger supports in place.

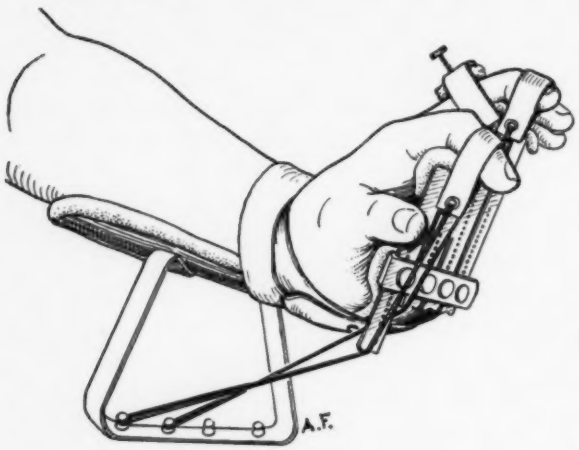

FIG. 2

Oblique view showing splint *in situ*.

thick, which is glued to adhesive overlying the duraluminum. The bridge is one-eighth of an inch by five-eighths of an inch wide, its exact position depending upon the degree of extension contracture of the fingers. When the contracture is complete, the bridge is about seven inches from the elbow; with less initial extension contracture, it is moved more proximal to the elbow. The finger supports glide in their appropriate tunnels, and are numbered corresponding to the fingers for which they are designed. They extend from the proximal to the distal creases of the fingers. Incomplete holes are drilled into the proximal two-thirds of the finger supports, three-sixteenths of an inch apart, and are made to fit knurled screws, which have an eight-thirty-seconds of an inch thread. The distal third is padded with sponge rubber overlying adhesive, as in the case of the forearm piece. The horizontal bar extends to the proximal crease of

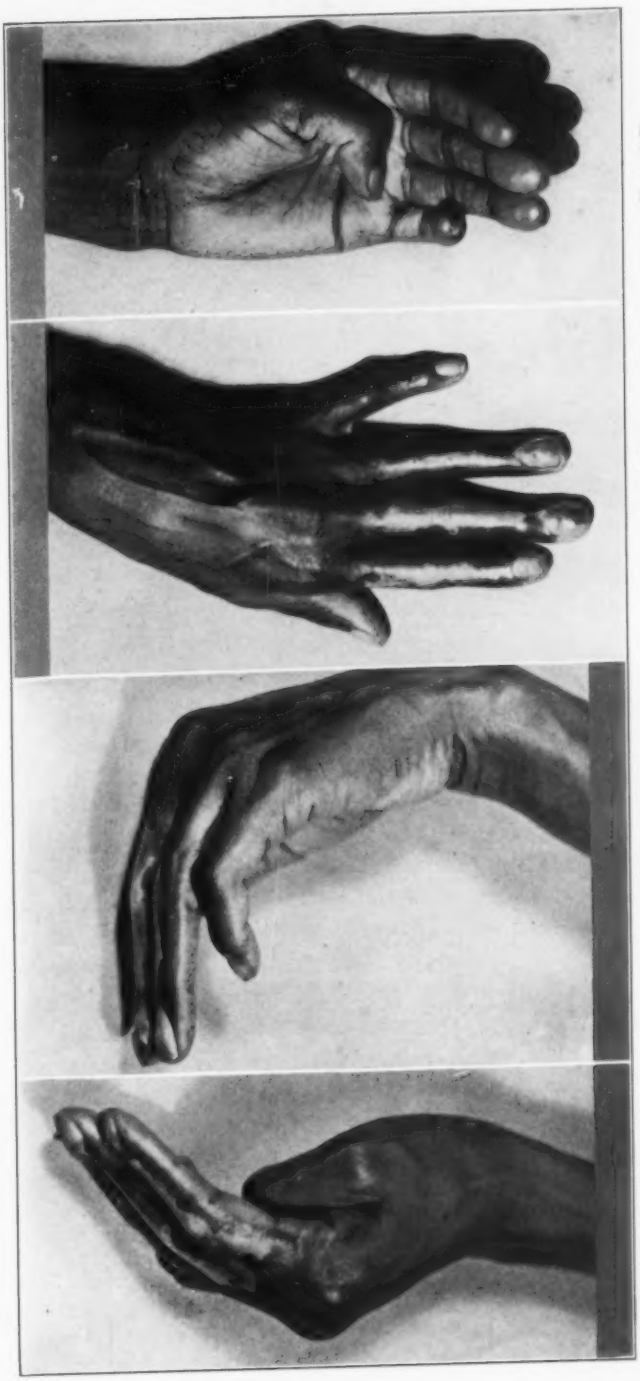

FIG. 3-A FIG. 3-B FIG. 3-C FIG. 3-D

Steam-press burn three months after the accident. Note absence of interphalangeal-joint motion.

FIG. 4-A FIG. 4-B

Two and one-half months later, following traction with the adjustable volar-flexion splint.

the hand and is partitioned into four tunnels to fit the sliding finger supports. Threaded holes, one for each partition, fit the knurled screws which, when tightened, make contact and fix the underlying finger supports. The finger clamps are made from 17-gauge stainless steel, measuring three and three-quarters of an inch by one-half inch in width. Each is bent into a U shape just wide enough to slide easily on the finger support. The screw has an eight-thirty-seconds of an inch thread with a knurled head, and is seven-eighths of an inch in length. A small pressure plate is riveted to the screw after it is inserted into the clamp. This plate measures three-quarters of an inch by one-half an inch and is made from 17-gauge stainless steel. It is padded with heavy felt. The finger-traction attachments are made of soft leather, seven-eighths of an inch wide and four inches long, which is bent on itself to form a loop. Holes which are punctured through each end allow an elastic rubber band to be attached for traction purposes.

Figures 3-A, 3-B, 3-C, 3-D, 4-A, and 4-B show the degree of motion which the patient had before and after treatment with the splint.

The author wishes to express his thanks to Mr. Schwartz of the Brace Department for his technical assistance in the construction of this brace.

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SCIATIC PAIN: ITS SIGNIFICANCE IN THE DIAGNOSIS OF CAUDA EQUINA TUMORS

Report of Four Cases

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Based on extensive studies of "sciaticas of unknown origin", Mixter and Barr, Love and Walsh, and Spurling and Grantham have focused attention on the "sciatic syndrome" which is due to a herniation of a nucleus pulposus or a hypertrophied ligamentum flavum. The criteria set forth by these authors are well known; but they have been invoked so universally that other causes of protracted unilateral sciatic pain are apt to be overlooked.

The need for a carefully detailed history, followed by an equally careful physical and neurological examination for every patient complaining of protracted pain down one extremity, hardly needs emphasis; but, when the various causes for such disability—as for example, traumatic conditions of the spine, postural defects, arthritis, foci of infection, metastatic foci, inflammations, and vascular changes—are thoroughly eliminated, one begins to suspect hysteria, malingering, or compensation neurosis as an explanation for the pain.

It is the authors' purpose in this paper to point out that sciatic pain may continue for varying periods as a result of a tumor of the cauda equina, and yet repeated examinations fail to show any abnormal objective finding.

In short we are forced to admit that the early diagnosis of neoplasm of the cauda equina is almost entirely a laboratory procedure. Once suspicion of the existence of a cauda equina tumor is aroused, the patient should be hospitalized, so that systematic diagnostic measures may be carried out to establish fully the presence or absence of a new growth in that region.

Only passing mention is made by Frazier and Allen, Elsberg, Wechsler, and Wilson of the occasional occurrence of a cauda equina neoplasm with very few or no abnormal neurological findings. Mixter [8] gives a case report of a patient who showed no abnormal neurological signs, but who at operation was found to have a neoplasm of the cauda equina. Of greater interest is the case, reported by Mulrooney and Love in 1938, of a woman who twice entered the Mayo Clinic for treatment of backache with sciatic radiation. The diagnosis upon first admission was radiculitis,

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but during the second admission, in spite of negative neurological findings and normal spinal-fluid total protein, lipiodol was injected intrathecally, and showed an arrest at the second lumbar vertebra. At operation a neurofibroma, one and five-tenths centimeters by one centimeter, was removed from its attachment to the third lumbar root.

The diagnosis in the above case was made as a result of lipiodol studies, and, fortunately, at a stage which permitted an excellent surgical result. But this experience, as is so well pointed out by Allen, is indeed rare. Only too frequently do patients with tumors of the cauda equina make their hospital appearance when the neurological signs are incontrovertible. With the aid of more refined diagnostic methods, it is no longer necessary for these patients to continue having pain until there is unequivocal evidence of paresis, sensory demarcation, and impaired sphincter control. When these are present, irreversible pathological changes may have already taken place.

In the great majority of these cases, therefore, early diagnosis is the only hope for complete and successful removal of the neoplasm. In the four cases here reported the diagnosis was made before there were any abnormal neurological signs.

CASE 1. A Hungarian-born housewife, aged forty-five, was admitted on October 30, 1937, complaining of intermittent low-back pain radiating to the left buttock. Eight months previously she was hospitalized for acute coronary occlusion and acute cholecystitis and cholelithiasis. Shortly after leaving the hospital she noted the onset of intermittent shooting pains across the lower back, which radiated down the posterior aspect of the left thigh and leg. Coughing, sneezing, or sudden movement aggravated the pain. This gradually increased in severity until she was bedridden. However, there was no weakness of either leg and no sphincter disturbance. The position of greatest comfort was usually lying on the right side. Infected teeth were extracted, but this gave no relief from pain. She had lost about thirty pounds in weight since the previous admission.

Examination revealed a well-developed, slightly cyanotic female, who appeared older than her stated age. There was evidence of an old coronary occlusion, and tenderness over the right upper quadrant of the abdomen. Her blood pressure was 118 systolic, 66 diastolic. There were numerous varicose veins in the lower extremities, but no evidence of weakness or atrophy. Careful sensory examinations by several observers failed to reveal any convincing sensory defects. Examination of the back revealed tenderness of the spines of the fourth and fifth lumbar vertebrae. The Lasègue sign was present on the left. All deep reflexes were hyperactive. The abdominal responses were active and equal, and the Babinski toe sign was absent.

Roentgenograms of the lumbosacral spine showed slight osteo-arthritis. Spinal fluid showed no block, but was faintly xanthochromic. The Pandy test was four plus and the total protein 86.5 milligrams per 100 cubic centimeters. Lipiodol was completely arrested at the lower border of the third lumbar vertebra, giving a typical "cap" deformity (Figs. 1-A and 1-B). Laminectomy was performed (Dr. Kaplan), and a bluish, cystic, intra-arachnoid tumor, measuring three centimeters by one-half centimeter, was found anterior to the cauda equina and attached to one of the roots. The tumor was completely removed. The pathological report was of a meningocele with blastomatous malformation. The patient made an uneventful recovery in spite of her serious cardiac condition, and at the time of discharge, three weeks after the operation, she was free of pain and there were no abnormal neurological findings.

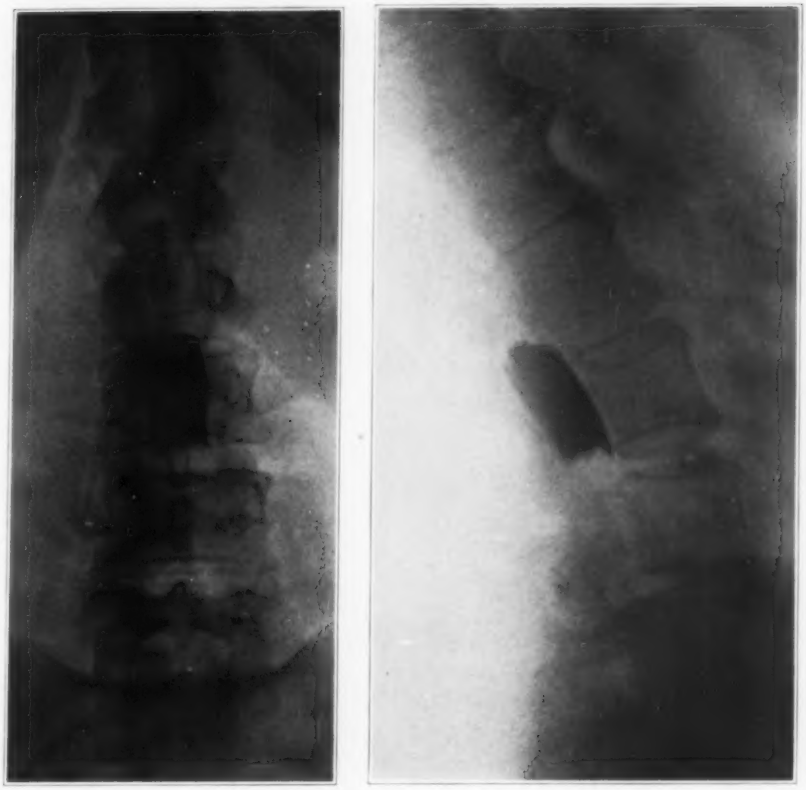

FIG. 1-A FIG. 1-B

Fig. 1-A: Case 1. Anteroposterior view showing typical lipiodol "cap" at the third lumbar vertebra.

Fig. 1-B: Lateral view showing lipiodol arrest. Also note the arthritic spurs in the bodies of the twelfth thoracic and the first lumbar vertebrae.

CASE 2. A bookbinder, thirty years of age, entered the Hospital on December 14, 1937, complaining of low-back pain and pains down both legs. Seven weeks before admission, while attempting to lift a man weighing 250 pounds, he felt a sudden ripping sensation, which started on the lateral aspect of the right leg and spread to the thigh. This uncomfortable sensation lasted only a second and was unassociated with back pain. One week later he began to experience a dull, intermittent ache, which started in the middle of the right thigh and spread down to the knee and ankle. Each attack of pain lasted about one-half hour. The right sciatic nerve was injected without benefit. Three weeks before admission he first noted pain across the lower back while bending forward. A fortnight later the pain began to radiate down the posterior aspect of both thighs.

The general physical examination was normal. There was lumbar lordosis and spasm of the paraspinal muscles, with tenderness over the lower lumbar and sacral vertebrae. The muscles of the right gluteal region, right thigh, and lower abdomen were flabby, and occasional fasciculations were noted on muscular contraction. Careful sensory examination failed to show the slightest abnormality. All the deep reflexes, including the ankle jerks, were hyperactive. The abdominal responses were intact. The Lasègue sign was present bilaterally.

Spinal fluid showed no evidence of block, and the total protein was 100 milligrams per 100 cubic centimeters. Lipiodol was completely arrested at the lower border of the third lumbar vertebra (Figs. 2-A and 2-B).

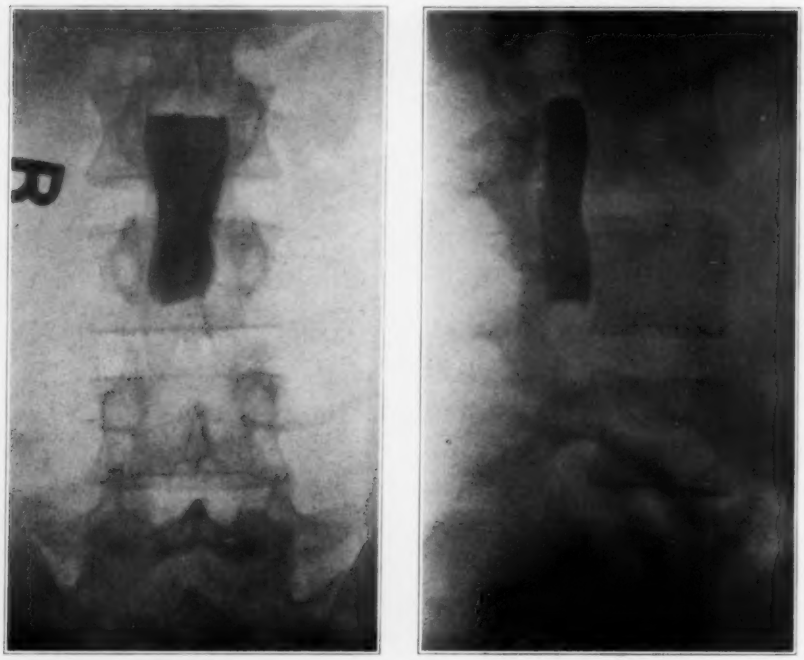

FIG. 2-A FIG. 2-B

Case 2. Anteroposterior and lateral views showing lipiodol arrest at the third lumbar vertebra.

The operation performed (Dr. Kaplan) several days later disclosed a soft, vascular, friable tumor, which was intra-arachnoid, and situated anterior to the roots of the cauda equina. This neoplasm was completely removed, and subsequently was reported to be a neuroblastoma. Recovery was uneventful. After a full course of radiation therapy the patient was discharged with no complaints and no abnormal neurological signs.

CASE 3. An obese Italian housewife, aged thirty-four, was admitted to the Hospital on February 21, 1941, because of pain in the right leg of three years' duration. Fifteen years and again six years before admission, the patient skidded down a flight of stairs without any ill effects. Three years before admission she began to experience spasmodic, "pulling" pains in the right gluteal region, which were aggravated by changes in position. Roentgenograms of the spine at this time revealed considerable arthritis. She was given injections of vaccine therapy into the sciatic nerve and after several months there was marked improvement. Eighteen months later there was an exacerbation of the pain which now began to radiate down the right thigh. Roentgenograms of the lower spine showed "spinal curvature and arthritis". Injections of the sciatic nerve were repeated, but were ineffective. One year before admission the pain became so severe, she had to discontinue her housework. For six months the pains across the lumbosacral region were associated with pulling, spasmodic pains, arising at the umbilicus and radiating to the right lower quadrant of the abdomen and to the front of the thigh. Bending, coughing, or straining greatly intensified the pain.

Examination revealed an obese (230 pounds), well-developed female, obviously in severe pain. Roentgenograms showed an enlarged gall bladder containing three stones. The remainder of the general examination was negative. Any extension of the legs caused a severe exacerbation of the pain, and the patient preferred to sleep in the sitting position. There was tenderness over the lumbosacral area, and movements of the lumbar spine were restricted. However, there was no weakness or atrophy of the right

leg. Sensory examination was completely negative. Repeated neurological examinations showed no motor, sensory, or reflex abnormalities.

Roentgenograms of the spine gave evidence of marked productive spondylitis from the sixth to the ninth thoracic vertebrae, and some arthritic involvement in the lumbar segments and in the sacro-iliac synchondrosis.

Spinal fluid showed no block; it was clear,

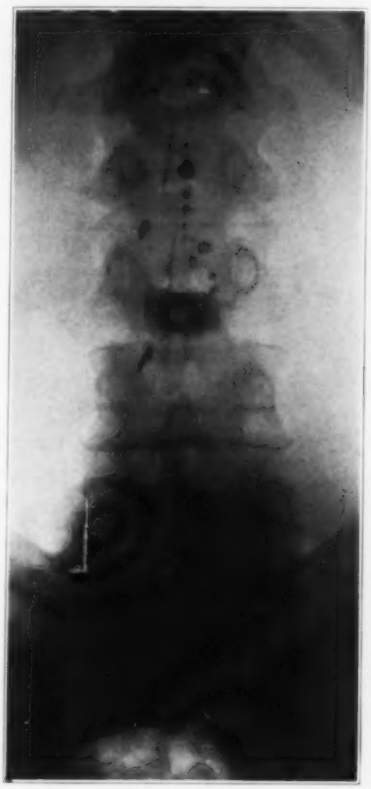

FIG. 3-A

FIG. 3-B

Case 3. Anteroposterior and lateral views showing lipiodol arrest at the lower border of the third lumbar vertebra

but faintly xanthochromic, and within a few minutes clotted spontaneously (Froin's syndrome). Total protein was 338 milligrams per 100 cubic centimeters. Lipiodol was arrested at the upper border of the fourth lumbar vertebra (Figs. 3-A and 3-B).

Laminectomy (Dr. Kaplan) disclosed an intradural tumor (Fig. 3-C) attached to the fifth lumbar nerve root on the right. The growth was completely removed and proved to be a schwannoma. The postoperative course was uneventful. Three weeks after operation she was discharged, completely free of pain, and to date is carrying on her household duties without any discomfort or difficulty.

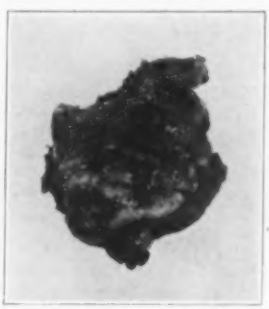

FIG. 3-C

Case 3. Extradural tumor removed from the fifth lumbar nerve root (actual size).

CASE 4. In July 1941, an American housewife, thirty years of age, was admitted to the Hospital, complaining of severe backache. One year before, she had fallen, bruising the right hip, and a month later she had begun to have pains across the lower spine, radiating down the lateral and medial aspects of the left leg. The pain gradually increased in severity and was intensified by coughing, sneezing, or straining. For two months she was unable

FIG. 4

Case 4. Neoplasm removed from the fourth lumbar nerve root (× 2).

to straighten out the left leg, and had to be helped in and out of bed.

The general physical examination was completely negative, and repeated neurological examinations by various observers failed to disclose any abnormality. Roentgenograms of the spine were negative. Spinal puncture showed no block; the fluid was xanthochromic and clotted spontaneously (Froin's syndrome). The total protein was 380 milligrams per 100 cubic centimeters.

Upon operation (Dr. Kaplan) an intra-arachnoid, cystic neurofibroma was found attached to the fourth lumbar root on the left (Fig. 4). The postoperative course was excellent, and by the end of the third week the patient was discharged completely well, and has remained symptom-free since then.

CONCLUSION

With the increasing tendency to regard low-back pain from the standpoint of prolapsed nucleus pulposus, and hypertrophied ligamentum flavum, it seems worth while to call attention to the fact that tumors of the cauda equina may exist without motor, sensory, or reflex changes. The authors' experience leads to the conclusion that if back pain is persistent, the patient should be given the benefit of a thorough clinical investigation, including roentgenograms of the spine, manometric test, analysis of spinal fluid particularly for total protein, air myelography, and, if need be, lipiodol studies.

SUMMARY

In none of these four cases of "sciatica", in which cauda equina neoplasms were discovered and removed, was there any motor, sensory, reflex, or sphincter disturbance when the diagnosis was made. In each case the diagnosis was established by the combined study of the spinal fluid and intraspinal lipiodol injection.

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TRAUMATIC BILATERAL SEPARATION OF THE LOWER FEMORAL EPIPHYSES

BY J. ALLEN KAPLAN, M.D., SETH B. SPRAGUE, M.D., AND HAROLD C. BENJAMIN, M.D., JERSEY CITY, NEW JERSEY

From the Orthopaedic Service, Jersey City Medical Center

Separation of the lower femoral epiphysis is quite rare. Separation of the epiphysis without a concomitant fracture is rarer. The authors are, therefore, presenting this unusual case of a bilateral separation of the lower femoral epiphyses without accompanying fracture, and at the same time, are presenting one way in which such disabilities may be handled.

On June 27, 1940, the patient, who was an eleven-year-old male, had both legs forcibly hyperextended at the knees. The child was sitting on a park bench with both feet extended through the back of the seat. Another child fell off a tree and overturned the bench. The patient's legs were thus hyperextended. He suffered immediate disability and was carried home. Thence he was brought to the Jersey City Medical Center.

Examination at admission showed marked diffuse swelling of both knees. There was no discoloration. Pain was elicited with any motion, but was most marked when the feet were dorsiflexed. Any attempt at minimal flexion of the knees resulted in exquisite pain. There was abnormal mobility in the anteroposterior and lateral directions.

Roentgenograms, which were taken immediately, revealed a pair of completely separated distal epiphyses of the femora. The proximal articulating surfaces of the epiphyses were in contact with the anterior surfaces of each femur (Figs. 1-A and 1-B).

The patient was immediately prepared for the operating room. Cyclopropane anaesthesia was administered and straight traction was applied to the right extremity. The right leg was then forcibly flexed under the thigh, and gentle pressure was made over the epiphysis.

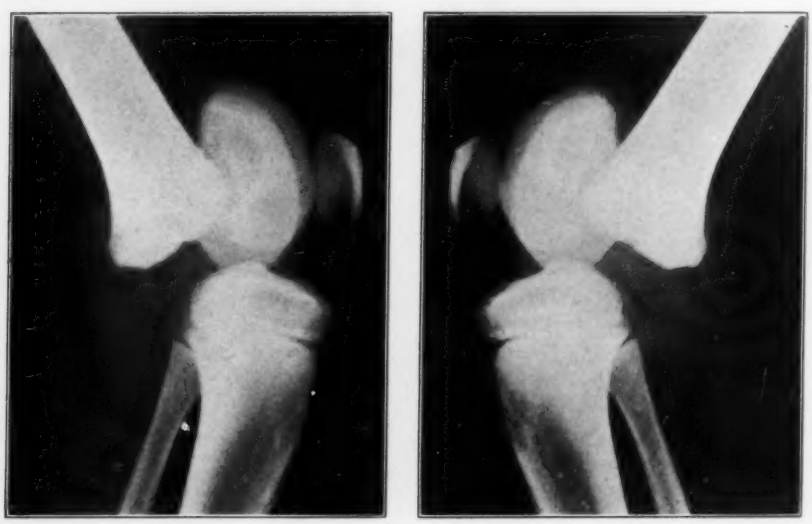

FIG. 1-A FIG. 1-B

Roentgenograms of left and right knees at time of admission.

FIG. 2-A FIG. 2-B

Roentgenograms of left and right knees showing reduction of displaced epiphyses.

The latter was felt to slip into place. The left extremity was then similarly treated. Circular casts were applied with both legs held in acute flexion. The casts extended from the toes to the groins. The reductions took place within an hour after admission to the hospital.

Check-up roentgenograms were taken before the patient was returned to the ward. They showed restoration of normal position (Figs. 2-A and 2-B).

The postoperative course was uneventful. The patient was quite comfortable in spite of what would appear to be an awkward position. On July 26 interval roentgenograms showed that the corrected positions were maintained. On July 31 new casts were applied, because the original set had become somewhat loose and soft. On August 20, approximately eight weeks after the original injury, the casts were removed. Roentgenograms showed good position and apparent healing (Figs. 3-A and 3-B). As was to be expected, the child at first had some difficulty in extending his legs. No passive motion was instituted, but whirlpool baths were prescribed. Within a period of ten days the knees were actively extended to 130 degrees. By September 1, 1940, approximately two months and two weeks after the date of injury, the patient was able to walk without any support. At this time massage, and active and passive exercises were given. One month later the patient was walking without any limp and did not have any limitation of motion.

A roentgenogram taken on November 4, five months after the accident, showed perfect healing.

FIG. 3-A FIG. 3-B

Roentgenograms of left and right knees immediately after removal of the casts.

TWO SMALL WIRE SPLINTS FOR THE TREATMENT BY TRACTION OF FRACTURES AND DEFORMITIES OF THE FINGERS AND METACARPAL BONES

BY JOHN LYFORD, III, M.D., BALTIMORE, MARYLAND

From the Division of Orthopaedic Surgery, the Johns Hopkins Hospital, Baltimore, Maryland

For fractures and deformities of the fingers and metacarpal bones best treated by traction, a small wire splint, similar to a Thomas splint, frequently can be used, doing away with the need for cumbersome hand casts. The splints described here have certain advantages, in that the operator can make and apply them easily and quickly; they are adjustable as to length, making changes in the amount of traction convenient; they allow for greater mobility of the hand and comfort to the patient; and in properly chosen cases obtain good results.

Wire such as is used in coat hangers is shaped as is shown in Figure 1-A. Several layers of two-inch adhesive tape are placed about the wrist to act as padding. One half-ring is placed dorsally and the other ventrally about the wrist, distal to, but resting against the ulnar and radial styloid processes respectively, and with the side bars extending out beyond the fingers. The rings are then held firmly in place by several more layers of two-inch adhesive tape placed about the wrist over the rings. The loop with the V notch is then taped to the side bars at the point best suited to give adequate traction which is supplied by rubber bands attached to the V notch. Either skin traction or skeletal traction with a silver wire placed through a phalanx can be used. The completed splint applied is shown in Figure 1-B. The position of the bars over the dorsal and palmar surfaces of the hand prevents flexion of the finger, which would tend to angulate the fracture fragments. If an adjustable splint is not desired, the splint can be made from a single continuous piece of wire.

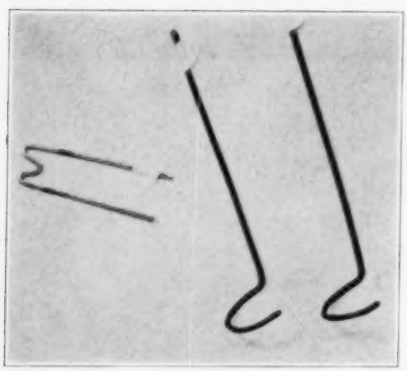

FIG. 1-A

The parts of the phalangeal and metacarpophalangeal splints.

FIG. 1-B

The metacarpophalangeal splint applied.

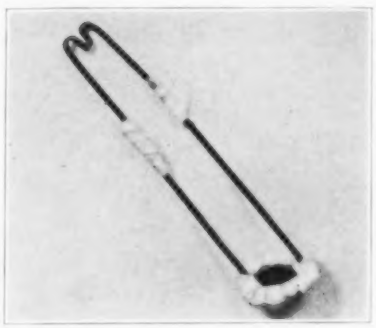

FIG. 2-A
The phalangeal splint.

FIG. 2-B
The phalangeal splint applied.

A smaller splint can be used if greater mobility of the hand is desired when treating fractures of a middle phalanx or contractures about a proximal interphalangeal joint. For this smaller phalangeal splint the wire is cut and shaped as for the larger metacarpophalangeal splint (Fig. 1-A). The half-rings are superimposed as mirror images, adjusted to fit the diameter of the base of the finger, and wrapped with adhesive tape to hold them securely together and to act as padding to protect the skin. The loop with the V notch is then taped to the side bars at the point best suited to the length of the finger. The completed splint (Fig. 2-A) is placed on the finger with the ring resting snugly between the fingers and adjusted so that it will rest as much as possible against the head of the corresponding metacarpal bone, and allow for the angle of the interdigital webbing. The phalangeal splint applied is shown in Figure 2-B.

AN IMPROVED ISCHIAL SEAT BRACE

BY WALTER I. GALLAND, M.D., NEW YORK, N. Y.

From the Orthopaedic Service, Lenox Hill Hospital, New York

In July 1936 the author published a description of a brace to which the term "ischial seat brace" was applied.[1] In this brace the Thomas ring is replaced by a small comma-shaped seat, upon which the ischium rests. This brace has been used by the author and his colleagues for the past six or seven years, and they have been able to effect the transferal of the body weight to the ischium in a highly satisfactory manner. Continued experience with this apparatus, however, has led to modifications in the original design which have increased both the effectiveness and the comfort of the brace.

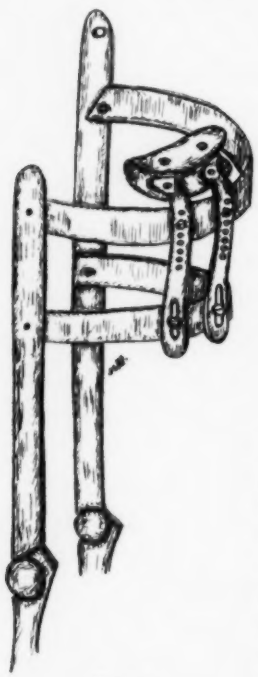

FIG. 1

The framework illustrating the new form of ischial seat, viewed from the posterior medial aspect. The upper surface of the seat bears the patient's weight in the standing posture. When the patient is seated with the hip flexed to 90 degrees, the anterior curved surface is contacted. The framework is of course adequately padded.

The original seat as described is a padded comma-shaped piece of metal, fashioned so that its superior surface is concave. The ischium rests upon the seat at the head of the comma. For the most part such a seat can be adjusted so that it is well tolerated by the patient, but the precise adjustment of the seat is made difficult by the fact that, when the patient is seated, the edge of the ischial saddle cuts into his flesh. For this reason, in the original description, an alternative design was described, in which the seat is placed upon a pivot, so that it swings around on its axis, presenting the padded concave surface to the patient, so that, whether he sits or stands, his weight is upon the surface of the seat. This latter design adds considerably to the expense of the brace, and it has been found that, particularly in stout patients, it is difficult to make the seat pivot and thus avoid cutting by the edge, described above. To avoid this edge contact, a new seat has been designed, which has obviated the above difficulties, and considerably simplified the device.

Instead of the original comma-shaped seat, the new design is so constructed that, in either the standing or the sitting posture, a flat padded surface is in contact with the ischial region. The seat has been greatly simplified in accomplishing this. It is no longer comma-shaped, and is made in the form of a plate bent around an arc of 180 degrees (Fig. 1). The superior surface of this bent plate is of a size sufficient to cover the

ischium entirely, and is usually about one and one-half inches deep and two inches long. The anterior surface of this angulated seat is of similar dimensions. The bending of the plate is rounded, rather than sharp, in order to avoid any uncomfortable edge pressure. Two posts support this seat and make contact with the thigh band of the brace according to the design illustrated (Figs. 1 and 2). Provision is made for adjustment of the height of the seat by means of set screws.

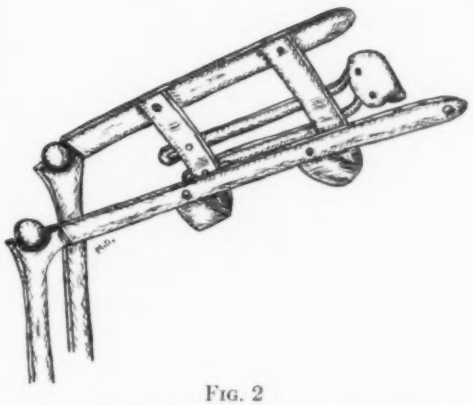

FIG. 2

The framework of the brace viewed from the lateral aspect with the knee flexed. The curved anterior surface of the brace takes the seated weight, thus avoiding the uncomfortable edge pressure of the original type of seat.

It will be obvious that, in either the erect or the sitting posture, the patient will be resting upon a padded surface instead of on a sharp edge. The pressure at all times can be made tolerable. The angulated seat obviates the necessity for a pivoted seat, and thus reduces the cost of the brace. Using this seat over a period of more than two years with at least thirty patients, it has been found to be extremely effective, reasonably comfortable, and admits of accurate adjustment to the ischium, so that the weight of the body is entirely shunted from the extremity through the brace to the ischium.

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HENRY TURNER

1858–1941

Henry Turner was born in Russia, of English parents, and received his education, academic and medical, in that country. His inheritance undoubtedly had an influence on his character, for his parents had long been residents there and his life was spent in its service as a Russian citizen.

After completing his medical studies, he entered into the practice of surgery and at once became active in hospital work. At that time, the specialty of orthopaedic surgery was not well defined in Russia, but his interest and inclination guided him strongly in that direction, and to this chosen work he devoted the best of his efforts throughout his life. Early in his career he became engrossed in the problem of the crippled child. Under the regime at that period, there was little or no provision for the care of this group, but he realized their need of special care and became absorbed in the treatment and rehabilitation of these people, and to the solution of this problem he devoted much of his time and of his best effort, in addition to his regular orthopaedic work, hospital and private. By his individual efforts he established a Clinic which developed into an important Hospital—the first of its kind in that country—and there he gave to these children of his skill in treatment and of his solicitation for their general welfare and development, by providing opportunities for their education and for training in handicrafts. At this period the special provision for the treatment and care of the crippled child was pioneer work,—not only in Russia, but in the world. He always took a personal interest, over and above the professional, in every child in the Hospital, and his devotion to them was reflected in the expression of their unusual affection for him.

Appreciation of his services in developing this work in his country was shown by the Government a few years ago, by building for him in the vicinity of Leningrad, a Hospital of 500 beds for the care of these patients. Dr. Turner received many honors in recognition of his services and accomplishments and of the position which he held in the community. At the fiftieth anniversary of his graduation, the completion of half a century of work in his chosen field, he was presented with a portrait which represented him as a blacksmith forging the health of the cripple and portrayed very strikingly the strength and kindliness which were among his attributes. In 1936 he was given the decoration of the Red Star, the highest honor which his Government could bestow upon him.

Dr. Turner was essentially a leader, and throughout his long life devoted much of his time to teaching and to developing the departments for carrying on the work in his special field of orthopaedic surgery, both in the Hospital and in the University of Leningrad where he held the Chair of Professor. He possessed the ability to enthuse his students, and gathered around him an able group of coworkers who, inspired by him, carried away with them the principles and ideals which he had imparted to them.

He was international in his interests and associations, and he was a frequent visitor to other countries and a representative at the meetings of their medical societies. His command of several languages facilitated his activity at these meetings and gained for him a host of foreign friends and admirers who welcomed him for the breadth of his knowledge and were attracted by the charm of his personality.

His scientific spirit and interest in guiding and giving ideals to the younger men which would stand by them later in establishing their own careers, and his directness of purpose made him a pioneer in his field of work. That his life was one of accomplishment was evident by the position he filled in his country and in the institutions in his community, as well as by the esteem in which he was held by his coworkers and by the devotion of the followers whom he had trained.

The visitor to Dr. Turner in recent years was impressed by his keenness of mind

HENRY TURNER

and the eagerness he manifested in gathering information about his professional friends and colleagues scattered throughout the world. He had carried on an intimate correspondence with friends he had never met, and in the latter years he was living among his books and his memories.

His extensive international contacts, which his command of languages made possible, his broad interests in affairs outside his medical life, and his familiarity with the classics gave to him an equipment which made him an outstanding figure, and his worth was recognized by all who had the opportunity of associating with him.

MARK HOMER ROGERS

1877–1941

Mark Rogers was born in South Sudbury, Massachusetts, and received his early and medical education in Boston. He was graduated from Williams College in 1900 and from Harvard Medical School in 1904. While in college his principal interest lay in those subjects which were fundamental to his later medical training. After serving a hospital internship in Boston, he entered at once into the practice of orthopaedic surgery.

He filled the position of Orthopaedic Surgeon at the Massachusetts General Hospital for twenty years. He also served on the orthopaedic services of the City Hospital and the Deaconess Hospital, and was chief of the orthopaedic consultants of the Beth Israel Hospital.

Dr. Rogers was always interested in teaching and, in addition to his hospital services, devoted much time and effort to it. He was an Associate in Orthopaedic Surgery at Harvard Medical School, and was Assistant Professor of Orthopaedic Surgery at Tufts Medical School from 1915 to 1924 and held the Chair of Professor from that date until he died.

He was a member of the principal national and local medical societies, including the American Medical Association, The American Orthopaedic Association, and The American Academy of Orthopaedic Surgeons, and his wide interests were evidenced by the large number of societies and institutions with which he was associated in different capacities.

During the World War he served as an officer in the Medical Corps from 1917, and at the end of the War he was discharged to the Reserve Corps as Lieutenant Colonel. He retained his interest in this national medical department by serving as consultant in the United States Public Health Service.

Known to his friends in the medical profession as one on whom they could depend, he was called to fill places where considered council was needed. To few men have come the opportunities for such service as was shown by the long list of hospitals to which he was consultant or an active member of the staff. His many medical friends realized that the same quality was expressed in other fields, and he was interested in many others than his medical duties. In his home town of Belmont, Massachusetts, for many years he was Chairman of the Playground Committee, and it was through his vision and guidance that the town has some of the best facilities and best planned policies for playground and recreational opportunities. His interest in the development of the youth was not confined to his town alone, for up to the time of his death his interest in his Alma Mater was unflagging. He was a constant attendant at the reunions and assemblies of the Alumni, and his associates always looked forward to meeting him at these gatherings for they appreciated his intellectual, gracious, and conservative qualities.

Another side was his love of music. He had shown particular fondness and talent for music in college, where he had taken part in the musical activities. He was organist for the College Chapel Choir, Manager of the Musical Association, and a member of the College Glee Club. For many years he was organist at All Saints' Church in Belmont. He also served his church as vestryman. As Choirmaster of this church came another opportunity for the expression of his love of music. It was a touching tribute to him that at the memorial services most of the original choir he had trained returned to sing.

To him came the satisfaction of having carried on to the end the chosen work of his life, and to his friends in all spheres of life he has left memories of work well done and a life well lived.

News Notes

The Seventh Annual Meeting of the **Orthopaedic Guild** was held in Detroit, Michigan, on November 21 and 22 under the chairmanship of Dr. C. L. Mitchell.

Dr. H. Theodore Simon announces that Dr. Irvin Cahen is now associated with him in the practice of orthopaedic and fracture surgery. Their address is 2000 Tulane Avenue, New Orleans, Louisiana.

Dr. Robert D. Schrock and Dr. Herman F. Johnson announce the association with them of Dr. Chester H. Waters, Jr. in the practice of orthopaedic surgery. Their office is in the Medical Arts Building, Omaha, Nebraska.

Dr. Russell F. Sullivan of Boston has been appointed to the Professorship of Orthopaedic Surgery at Tufts Medical School, succeeding Dr. Mark H. Rogers.

The Sixth Semi-Annual Meeting of the **Tri-State Orthopedic Society** was held in Cincinnati, Ohio, on October 27, 1941. An interesting program was presented by the Cincinnati members at the Children's and General Hospitals.

The next meeting will be held in Huntington, West Virginia, in April 1942.

The Scottish Board of Health, some months ago, asked the Canadian Red Cross to secure for them if possible the assistance of a **Canadian Orthopaedic Unit.** The request was turned over to the Canadian Medical Association who appointed a subcommittee to organize an orthopaedic unit for service in Scotland in one of the hospitals of the Emergency Medical Service.

This unit has already been organized and in December proceeded overseas. It is in charge of Dr. A. B. LeMesurier, with the following orthopaedic personnel: Dr. A. B. LeMesurier, Dr. F. R. Wilkinson, Dr. H. H. Campbell, Dr. H. J. Kellam, Dr. L. M. Hampson, Dr. R. L. Stirritt, Dr. G. E. P. Wilson, Dr. J. W. Sparkes, Dr. P. F. Mcgoey.

Twenty-one nurses were included in the unit, Miss Alice Hunter being nurse-in-charge. The unit will be stationed at Stracathro Hospital, Scotland.

The Government is faced with a critical need for physicians to serve as Associate Medical Officers in the Federal Civil Service in such agencies as the Veterans Administration, the U. S. Public Health Service, the Indian Service, and others. In August of 1940, the Civil Service Commission announced an examination to fill Medical Officer positions of various grades in the Government Service. This examination has been closed and reannounced with certain modifications. Applications will be accepted until further public notice.

The examination covers three grades: Associate Medical Officer, $3,200 a year; Medical Officer, $3,800 a year; and Senior Medical Officer, $4,600 a year. Applicants for the Medical Officer grade must have graduated from a medical school (Class A) since May 1, 1920, and for the Associate grade, since May 1, 1930. No specified time limit is set for graduation for the Senior grade.

No written test is required. Applicants are rated upon their education and experience. The maximum age limit for all grades has been raised to fifty-three.

Announcements and application forms may be obtained at any first-class or second-class post office, or from the Civil Service Commission, Washington, D. C.

The Tenth Annual Convention of **The American Academy of Orthopaedic Surgeons** will be held in Atlantic City, New Jersey, January 11 through January 15, 1942, under the presidency of Dr. Oscar Lee Miller of Charlotte. The headquarters will be the Chalfonte-Haddon Hall Hotel.

The scientific program planned by the Committee is as follows:

MONDAY, JANUARY 12

Morning Session

Two Cases of Late Rupture of the Extensor Pollicis Longus Tendon Following Colles' Fracture.
Edwin Weinberg, M.D., Baltimore, Maryland.

The Steinmann Pin in Fracture Fixation.
O. Anderson Engh, M.D., Washington, D. C.

A Report of Thirty Cases of Osteochondritis Dissecans.
Lt. Comdr. Robert Mazet, Jr., U.S.N.

The Army Medical Corps.
Col. George Lull, U.S.A. (By invitation.)

The Clinical Use of the Chamberlain Technique in Back Examinations.
Randolph L. Anderson, M.D., Charleston, West Virginia.

Vitallium Replacement of Upper Two-Thirds of Femur, Following Nailing for Non-Union of Neck of Femur, Subsequent Bone Graft for Giant-Cell Tumor and Finally Resection of Bone.
Austin Moore, M.D., Columbia, South Carolina.

Congenital Synostosis of the Cervical Spine (Klippel-Feil Syndrome)—A Study of Case Reports.
H. Alvin Jones, M.D., Baltimore, Maryland.

Two Cases of Interscapulothoracic Amputation.
Major Leonard Petersen, U.S.A.

Afternoon Session

The Treatment of Fracture and Dislocation of the Cervical Spine.
William A. Rogers, M.D., Boston, Massachusetts.
Discussion: Custis Lee Hall, M.D., Washington, D. C.
C. Glenn Barber, M.D., Cleveland, Ohio.

Anterior Capsulotomy of the Elbow for Residual Flexion Deformities Following Fractures.
Philip D. Wilson, M.D., New York, N. Y.
Discussion: Donald Somers, M.D., Detroit, Michigan.
B. F. Buzby, M.D., Camden, New Jersey.

Pathology of Recurrent Dislocation of the Shoulder; Report of Bankhart's Operative Procedure.
Frederic C. Bost, M.D., San Francisco, California.
Verne T. Inman, M.D., San Francisco, California. (By invitation.)
Discussion: Toufick Nicola, M.D., Montclair, New Jersey.
Rudolph S. Reich, M.D., Cleveland, Ohio.

TUESDAY, JANUARY 13

Morning Session

Eosinophilic or Solitary Granuloma—Is It a New Disease?
William T. Green, M.D., Boston, Massachusetts.
Sidney Ferber, M.D., Boston, Massachusetts. (By invitation.)
Discussion: Thomas Ramsey, M.D., Toledo, Ohio. (By invitation.)
Harold A. Sofield, M.D., Oak Park, Illinois.

Rate and Amount of Increase in Muscle Strength Following Infantile Paralysis.
Robert L. Carroll, M.D., Los Angeles, California.
Discussion: C. H. Crego, Jr., M.D., St. Louis, Missouri.
William J. Stewart, M.D., Columbia, Missouri.
A. Bruce Gill, M.D., Philadelphia, Pennsylvania.

The Obturator Sign as the Earliest Roentgenographic Evidence of Hip Joint Infection.
Herman C. Schumm, M.D., Milwaukee, Wisconsin.
Vernon C. Turner, M.D., Milwaukee, Wisconsin. (By invitation.)
Hans W. Hefke, M.D., Milwaukee, Wisconsin. (By invitation.)
Discussion: Fremont A. Chandler, M.D., Chicago, Illinois.
Paul C. Colonna, M.D., Oklahoma City, Oklahoma.

A Study of Gross and Microscopic Lesions in Tuberculosis of the Spine.
Mather Cleveland, M.D., New York, N. Y.
Discussion: Walter P. Blount, M.D., Milwaukee, Wisconsin.
Edward L. Compere, M.D., Chicago, Illinois.

Afternoon Session

Prevention of the Hereditary Crippling Diseases.
William Allen, M.D., Charlotte, North Carolina. (By invitation.)

Calcification and Ossification of Semilunar Cartilages.
James B. Weaver, M.D., Kansas City, Missouri.
Discussion: David M. Bosworth, M.D., New York, N. Y.
G. E. Haggart, M.D., Boston, Massachusetts.

The Rôle of Articular Cartilage in Hypertrophic Arthritis.
George Wagoner, M.D., Haverford, Pennsylvania.
Discussion: Melvin S. Henderson, M.D., Rochester, Minnesota.
Frank N. Potts, M.D., Buffalo, New York.

WEDNESDAY, JANUARY 14

Morning Session

What Is Actually the Best Treatment of Acute Osteomyelitis.
Pedro S. Toledo, M.D., Havana, Cuba.

Experimental Osteomyelitis.
Philip Lewin, M.D., Chicago, Illinois.
Louis Scheman, M.D., Chicago, Illinois. (By invitation.)

The Value of Laminograph in the Treatment of Chronic Osteomyelitis.
Alan DeForest Smith, M.D., New York, N. Y.
Lawson E. Miller, M.D., New York, N. Y. (By invitation.)

The Report of the Use of Sulfonamides in Traumatic and Infected Wounds.
Lenox D. Baker, M.D., Durham, North Carolina.
Discussion of the above four papers:
Richard B. Raney, M.D., Durham, North Carolina.
Frederick A. Jostes, M.D., St. Louis, Missouri.
Guy A. Caldwell, M.D., New Orleans, Louisiana.

Treatment of Club Feet with Denis Browne Splints.
Stuart A. Thomson, M.B., Toronto, Canada. (By invitation.)

Afternoon Session

The Management of Associated Injuries in the Presence of Skull Fracture.
Harry E. Mock, M.D., Chicago, Illinois.
Discussion: Harold R. Conn, M.D., Akron, Ohio.
W. Barnett Owen, M.D., Louisville, Kentucky.
Temple S. Fay, M.D., Philadelphia, Pennsylvania.
(By invitation.)

President's Address.
Oscar Lee Miller, M.D., Charlotte, North Carolina.
Fusion of the Metacarpal of the Thumb and Index Finger to Maintain Functional Position of the Thumb.
Charles F. Thompson, M.D., Indianapolis, Indiana.
Discussion: Nicholas S. Ransohoff, M.D., New York, N. Y.
Percy M. Girard, M.D., Dallas, Texas.

THURSDAY, JANUARY 15

Morning Session

Extra-Articular Fixation and Bone Grafting of the Fractures of the Hip. Preliminary Report.
Juan Farill, M.D., Mexico City, Mexico.
Discussion: Robert Packard, M.D., Denver, Colorado.
Fred H. Albee, M.D., New York, N. Y.
The Orthopaedic Treatment of Hypertrophic Arthritis of the Hip.
John G. Kuhns, M.D., Boston, Massachusetts.
Surgical Treatment of Painful Hips in Adults.
Ralph K. Ghormley, M.D., Rochester, Minnesota.
M. B. Coventry, M.D., Rochester, Minnesota. (By invitation.)
Discussion of the above two papers:
Clarence H. Heyman, M.D., Cleveland, Ohio.
Arch F. O'Donoghue, M.D., Sioux City, Iowa.
Paul Magnuson, M.D., Chicago, Illinois. (By invitation.)
Robert V. Funsten, M.D., Charlottesville, Virginia.
Further Report on the Kenny Treatment of Infantile Paralysis.
Wallace H. Cole, M.D., St. Paul, Minnesota.

A new feature of the program this year is the Instructional Section. Fifteen different courses are offered, and the program has been so planned that time for these courses is allowed during the four days of the meeting, in the late afternoon and early morning periods. These courses are as follows:

Course No. I—Lame Back.
Course No. II—Roentgen Therapy.
Course No. III—Fractures.
Course No. IV—Arthritis.
Course No. V—Knee Joint.
Course No. VI—Vitallium Mold Arthroplasty.
Course No. VII—Bone Metabolism.
Course No. VIII—Surgery of the Hand.
Course No. IX—Disability Evaluation.
Course No. X—Foot Disabilities.
Course No. XI—Scoliosis.
Course No. XII—Bone Tumors.
Course No. XIII—Periarthritis of the Shoulder.
Course No. XIV—War Surgery.
Course No. XV—Club Foot and Congenital Deformities.

The faculty include men particularly fitted to give instruction in these subjects.

The Executive Sessions will be held at noon on Monday, January 12, and at eleven o'clock on Thursday, January 15.

The Program Committee has also given special emphasis to the motion picture program and has arranged different periods for these productions during the four days.

Attractive Scientific Exhibits and Technical Exhibits will be a feature of the meeting.

Several social events have been planned, culminating in the Annual Dinner on Wednesday evening, at which the scientific awards will be made.

Current Literature

TUBERCULOSIS OF BONE AND JOINT. G. R. Girdlestone, M.A., B.M. (Oxon.), F.R.C.S. (Eng.). London, Oxford University Press, 1940. $8.75.

This work takes its place at once in the front rank of texts on the subject. A record of the result of Mr. Girdlestone's long and extensive experience and of his careful study of the whole problem, embracing so many factors, is welcomed by all who have to deal with the difficulties encountered in the treatment of this disease. It is satisfying to have Mr. Girdlestone bring out so clearly, and to emphasize the necessity of recognizing the general character of this disease. This he does in his discussion of the general considerations, and he brings out the view of the primary infection of the lymph glands, which serve as a source from which the bacillus is distributed to the parts secondarily involved.

The title of the book is "Tuberculosis of Bone and Joint", and the author has concentrated his efforts on this subject. He has avoided the mistake of presenting in a book of this size too much of the well-accepted details, particularly of history and diagnosis. In the discussion of the differential diagnosis, the various diseases which come naturally under consideration are treated sufficiently in detail, both in regard to their symptoms and signs, to illustrate the essentials of comparison in making the differential diagnosis.

After the discussion of the general character of this disease and of the different factors which must constantly be borne in mind, the general trend and the methods of local and operative treatment are presented in a way to aid in determining the conduct which should be followed with this disease in its varied locations. The consideration which the author gives to this of itself emphasizes the necessity of regarding these local affections as a manifestation of a general systemic disease.

The different joints are taken up individually, and the main characteristics peculiar to each are given, and their importance, with a discussion of the choice of application of the various methods and means of treatment. His conclusions on the indications for and against some of the major operations are the result of careful observation and recording of the experience which comes with a study of long follow-ups and gives a practical opinion of the ultimate value of these procedures.

The reader will do well to study carefully the portion of the book dealing with diagnosis and the methods and means of treatment which are at his disposal. The author has given the proper emphasis to be accorded to the varied signs which present different degrees of virulence, and the grouping of the signs which must be taken into consideration shows experience and judgment. The book is not primarily for the student, but more for the orthopaedic surgeon who has to meet the difficult problem of the care of these cases, and who must decide on the method of conduct and choose the treatment. The directions which the author has given will be found a valuable guide in making the frequently delicate decisions when it comes to the choice of methods, both of conduct and of treatment.

It is impossible to study this book without arriving at a broader view of the conduct of these difficult cases, and without being impressed with the need of the recognition of the importance of all the factors involved in the treatment, which recognition adds to the patient's opportunity for recovery.

The book is profusely illustrated by drawings and line cuts and particularly excellent roentgenograms to demonstrate the essential points in the text.

ROENTGEN DIAGNOSIS OF THE EXTREMITIES AND SPINE. (Annals of Roentgenology, Vol. XVII.) Enlarged First Edition. Albert B. Ferguson, M.D. New York, Paul B. Hoeber, Inc., 1941. $12.00.

In this enlarged first edition of his well-known book, the author has added much valuable information to the chapter which deals with the vertebral column. Forty-six new roentgenograms and a discussion of vertebral anomalies—such as unilateral sacral-

ization, enlarged transverse processes with arthritis of the transversosacral joints, intraspinal protrusion of the intervertebral discs, and various abnormal conditions of the lumbar facets—have been incorporated. The presentation is excellent, and the new illustrations show the morbid conditions involved clearly and impressively. The first edition has met with so much interest that one may expect that the present enlarged edition will have to be reprinted soon. Perhaps it would be possible to include a bibliography then.

The basic idea of this work—namely, to present roentgenographic findings according to purely roentgenographic criteria—is a definite step in the right direction. The student of bone and joint lesions is confronted with the difficulty of understanding how the main roentgenographic phenomena, rarefaction and condensation, appear and combine in the various lesions. Dr. Ferguson's book is a good guide through the maze, although all roentgenologists will not agree with the roentgenological categories defined and established in his work.

This monograph is of great interest for all who have to deal with diseases of bone and joints; notwithstanding certain limitations, it represents a progressive and basically sound approach to this subject. As a description of the purely roentgenographic findings, it is perhaps the best introduction now available.

A Manual of the Treatment of Fractures. By John A. Caldwell, M.D. Springfield, Illinois, Charles C. Thomas, 1941. $3.50.

A manual, a small book, a handbook, necessarily is an outline of its subject. It is a great asset to have such an outline of fracture treatment from a large and busy clinic, and by a surgeon who has devoted much time and thought to the subject. Dr. Caldwell, the Editor, has used good judgment in selecting a few subjects from among common injuries, and has dwelt on the principles in the treatment followed at the Clinic of the Cincinnati General Hospital.

Several manuals dealing with the treatment of fractures have been published during the last few years. This manual of Caldwell's is the best one the reviewer has seen. It tells things which should be known about several fractures and directs treatment in a sane, safe, and effective manner. Principles of procedure have been stressed, so that the student will find reasons for the treatment suggested. This is a good manual and may be heartily recommended. The illustrations illustrate.

It is a minor criticism, but it certainly would be desirable in another printing of this manual to place the present final chapter on "First Aid and Emergency Treatment" in first position.

Arthritis in Modern Practice. The Diagnosis and Management of Rheumatic and Allied Conditions. Otto Steinbrocker, B.S., M.D. With Chapters on Painful Feet, Posture and Exercises, Splints and Supports, Manipulative Treatment, and Operations and Surgical Procedures, by John G. Kuhns, A.B., F.A.C.S., Philadelphia and London, W. B. Saunders Co., 1941. $8.00.

"Arthritis in Modern Practice" by Otto Steinbrocker, with supplemental chapters on related subjects by John G. Kuhns, is a very practical volume.

The authors are connected with the Arthritic Clinics at Bellevue Hospital in New York and the Robert Breck Brigham Hospital in Boston, respectively. The book opens with observations on the social and economic aspects of the subject matter, and an acceptance, in the main, of present-day classification of the various types of arthritic disturbance. The chapter on rheumatoid disease presents nothing particularly new, but emphasizes the significance of the sedimentation test, not so much from the diagnostic angle, as from that of its importance in determining when the activity of the process is on the wane. Sulphur, hyperthermia, and specific vaccines are not given very strong approval; the use of gold salts for the atrophic type receives quite favorable commendation. Osteo-arthritic (hypertrophic) lesions are adequately covered and conventionally treated. The increasing prominence of fibrositis as a diagnostic entity receives full recognition.

Gonococcal arthritis, syphilitic joints, and gout are fully discussed. To the reviewer it seemed that free opening and washing out of the fulminating type of Neisser joint, in order to avoid intractable adhesions, are not sufficiently emphasized. In speaking of intermittent hydrops, no mention is made of the very common occurrence of a striking periodicity in the attacks, so commonly noted in patients with this trouble.

The chapter on the painful shoulder deals with all the usual shoulder lesions. The one the author regards as the most common, fibrositis, recalls the term applied to this clinical entity three or four decades ago,—that is, periarthritis. The points especially stressed are the localized tenderness, and the employment of procaine to aid in the differentiation of the various lesions. Other conditions are, in the main, routinely treated. Probably the most suggestive chapters in the book are those in which the significance of localized pain is discussed, and those in which the techniques of the various injection methods, so commonly used in these days, are described. There is a detailed account of physical-therapy methods and specific exercises employed at the Robert Breck Brigham Hospital in an effort to rehabilitate the patient with chronic arthritis, supplementing a chapter on the importance of proper body mechanics, both for prevention and treatment. To completely round out the consideration of arthritis as it is at present being treated, considerable attention is given to the indications for, and the methods of applying manipulation to the various joints. The open operative measures employed to restore or improve function are also fully detailed, as are the many splints and mechanical devices used in treatment. Finally, a glossary is appended to enlighten the uninitiated in the language of the orthopaedic surgeon.

DISEASES OF THE BLOOD AND ATLAS OF HEMATOLOGY WITH CLINICAL AND HEMATOLOGIC DESCRIPTIONS OF THE BLOOD DISEASES, INCLUDING A SECTION ON TECHNIC AND TERMINOLOGY. Roy R. Kracke, M.D., Ed. 2. Philadelphia, J. B. Lippincott Co., 1941. $15.00.

This new edition of the excellent Hematology by Dr. Kracke will be welcomed by all working in this field of medicine.

Many of the chapters have been rewritten and expanded. In the chapter on hypochromic anaemia there is a useful table presenting different iron compounds with dosage and relative costs. A similar table regarding liver and liver preparations is included in the chapter on pernicious anaemia. Since the 1937 edition there have been many new developments in the treatment of leukaemia.

The section on blood groups and transfusion is larger than before, and includes many practical points which have been learned from the experience of those who have worked with blood banks. Many new procedures are found in the section on methods, which is an important part of the book. A chapter on hemoglobin and its derivation discusses the relation of hemoglobin to methemoglobin, sulphemoglobin, carbon monoxide hemoglobin, and other compounds. The section on porphyrins is valuable because this is a new field and of great importance in the study of blood disorders.

The classification of the hemolytic anaemias and the mechanism of hemolysis are discussed. Hemolytic anaemia due to chemicals, drugs, poisons, sulfonamide compounds, and hemolysins are better understood because of the work in recent years, and this section of the new edition is therefore of greater value.

The causes of hemoglobinuria, although as yet little understood, are classified according to exogenous and endogenous causes. Achrestic anaemia, tropical macrocytic anaemia, and ovalocytosis are new subjects taken up in the new edition. The section on hemorrhagic disease includes an important chapter on vitamin K. Much important work on this subject has been done since the first edition was published.

The section on bone marrow, covered in six pages in the first edition, requires twenty-one pages in the present edition. New diagrams and tables have been added. The additional space devoted to this section is in keeping with the increased interest and recognition of the value of bone-marrow studies. Different methods of studying the

bone marrow are given. A biopsy of the bone is extremely important in these unusual conditions of anaemia and leukaemia for it supplements the findings in the blood studies. The photomicrographs of the pathological sections of the bone marrow with the differential cell count are of diagnostic value to any who are working in this field.

The blood plates in color are always helpful to the hematologist. In this book there are more than forty, a few of which are new in this edition.

This work combines the clinical descriptions of blood diseases with a presentation of hematological methods, and is illustrated by many colored plates, thus making it a valuable handbook for the clinician as well as for the laboratory worker.

SYNOPSIS OF THE PREPARATION AND AFTERCARE OF SURGICAL PATIENTS. Hugh C. Ilgenfritz, A.B., M.D., and Rawley M. Penick, Jr., Ph.B., M.D., F.A.C.S; with Foreword by Urban Maes, M.D., D.Sc., F.A.C.S. St. Louis, The C. V. Mosby Co., 1941. $5.00.

In the general surgical field, there has been little recent change in operative procedures. Details may vary from time to time, but the accepted technique for the majority of operations is fairly well standardized. However, advances in treatment of surgical conditions from a physiological standpoint have been rapid and numerous. It is becoming more evident that future progress and success in surgery will depend upon a close cooperation between the surgeon and the scientific investigator. Already certain physiological facts in relation to preoperative and postoperative care have become standardized.

This volume of 480 pages, with fifty-five illustrations, covers thoroughly certain standardized physiological considerations important in the care of the surgical patient before and following operation. In certain conditions, such as intestinal obstruction, in certain studies, such as the pathological physiology of the liver, the thyroid, and the blood dyscrasias, important recent advances have been made. Often constitutional diseases have to be corrected and cardiac or renal conditions properly treated, if the surgical operation is to be successful. The present status of prothrombin in relation to the patient with a jaundiced gall bladder, and the advent of the sulfonamides are examples of recent advances in the care of the surgical patient. Controversial points and descriptions of various technical procedures have been omitted.

The volume as a whole is concise and compact, being almost a pocket manual. The book will prove of value to any one concerned with the preparation and after care of surgical patients.

WOUNDS AND FRACTURES. A. CLINICAL GUIDE TO CIVIL AND MILITARY PRACTICE. H. Winnett Orr, M.D., F.A.C.S. Springfield, Illinois, Charles C. Thomas, 1941. $5.00.

The book is nicely bound in a conveniently sized edition, and is excellently illustrated. The material is presented in a rather unusual manner, being somewhat didactic and testimonial in character,—in reality a textbook with illustrative cases. It lacks statistical evidence to confirm the author's claims. However, one can readily understand that it would be difficult to present adequately controlled statistics on the subject. The style of presentation is of the ex-cathedra type, and smacks of the publications of the later years of the nineteenth century.

The preface is long and a bit dull, but near the end the object of the book is more or less definitely stated; it is more definitely defined in the following paragraph quoted from the book:

"It is intended in this book to consider a series of fracture cases grouped by problems, as well as by regions; to describe certain successful technics, and to discuss fundamentals in treatment. In some instances failure to comply fully with sound principles necessitates secondary operations, such as refracture or repair. The attempt will be made to call attention to the reasons for success or failure of various 'methods'. It can be

shown, we think, that adherence to rules and principles, or departure therefrom, will serve to explain the efficacy—or inadequacy—of any particular apparatus or technic better than any statistics that can be adduced."

The Orr treatment of fractures has been given sufficient trial by reliable authorities in America and abroad to afford it a definite place in the armamentarium of the surgeon treating such conditions. Briefly, it consists of reduction of the fracture, the insertion of pins through the fragments, and the maintenance of the reduction by the aid of plaster-of-Paris casts in which the pins are incorporated. Compound fractures are treated in the same manner, the pins being inserted far enough away from the wound, so that there is no danger of contamination. The wound is completely cleansed, packed wide open with vaseline gauze, covered with a heavy dressing, and the cast is applied over all. Undoubtedly the author thoroughly appreciates the importance of roentgenograms taken before and immediately after reduction, as well as during convalescence, in these cases, but this is not sufficiently emphasized.

The details of Orr's procedure are described under the following headings: Fundamental Principles of Fracture Treatment; The Operative Treatment of Fractures; The Treatment of Non-union and Malunion; Compound Fractures with Infection; Fractures Involving Joints; Nerve Injuries in Fractures; Fractures of the Pelvis, Spine, and Hip; Fractures of the Foot and Hand; and First Aid, Medical Care, and Physiotherapy.

On the whole, the author proves his points. There is some repetition which might have been avoided, but this is an excusable error in one anxious to make certain fundamental points, which if unfulfilled will undermine and perhaps nullify all efforts.

The author disapproves of the use of ice tongs and wires for traction. He insists the pins he uses are held securely in the cast and in the bones, thus preventing the rocking motion which attends the use of smaller-sized wire and the ice tongs. His method eliminates the irritation and drainage in the flesh at the points of exit.

The author refers to Truetta's success with this method in the Spanish war. It is to be regretted that Truetta's reports have somewhat overshadowed Dr. Orr's, as the latter was the first to advocate the method. Truetta speaks of the treatment as the closed method, whereas Dr. Orr points out in his book that in so far as the wound in compound fractures is concerned, it is in reality an open method, the wound being left wide open; only the cast, with no window left for dressings, is closed.

The book is filled with timely practical suggestions which may prove very important in the present national emergency. There is ample evidence that, if this method is used properly in war wounds, many lives will be saved and many injured limbs will be restored to early and better function perhaps than by any other method.

CANCER OF THE FACE AND MOUTH. DIAGNOSIS, TREATMENT, SURGICAL REPAIR. Vilray P. Blair, M.D., Sherwood Moore, M.D., and Louis T. Byars, M.D. St. Louis, The C. V. Mosby Co., 1941. $10.00.

This book is the summary of the work of Blair and Byars from the surgical and plastic aspects and of Moore from the roentgenographic viewpoint. Cancer treatment today calls for just such a combination of workers in the various fields of medicine.

The writers deal at first in general considerations of treatment, with the underlying principles of surgical destruction or removal of a cancer, and the general care of the patient. More than half of the book is taken up by a very thorough discussion of cancer of different regions,—face, ear, nose, orbit, lip, tongue, floor of mouth, nasopharynx, antrum, salivary glands, and skin. Each chapter is illustrated by many photographs of patients before, during, and after treatment. Many plastic procedures were used in these cases, and the results of treatment after five years are given.

The chapter on operative technique consists of drawings of operative procedures, showing the details of the work done on patients pictured in the first portion of the volume. These drawings are very well done and are clearly explained in the legends.

THE FOOT AND ANKLE. THEIR INJURIES, DISEASES, DEFORMITIES AND DISABILITIES, WITH SPECIAL APPLICATION TO MILITARY PRACTICE. Ed. 2. Philip Lewin, M.D., F.A.C.S. Philadelphia, Lea & Febiger, 1941. $9.00.

The second edition of this treatise on the foot covers the subject completely. The text is well arranged, and the style is lucid and concise. The illustrations, with a few exceptions, are well chosen and clear.

Beginning with a discussion of the anatomy and embryology of the foot, the various chapters explain clearly the different ills which befall the human foot and their treatment. The chapter on the examination of the foot is especially praiseworthy and may well serve as a guide to those who are called upon to treat these disabilities. While many orthopaedic surgeons will not agree entirely with all of the treatment advised, the basic principles laid down in the book are sound.

This book should be very helpful to every orthopaedic surgeon and should be a valuable reference book for the chiropodist.

DIAGNOSTIC ROENTGENOLOGY. [Renewal Pages.] Ross Golden, M.D., Editor. New York, Thomas Nelson and Sons, 1941.

In these days when changes and advances in all departments of medicine and surgery are occurring so rapidly that there is almost a new order, not only in treatment but in diagnosis, it is of advantage and of value to have a record of the recent contributions to attach to the record of the preceding period. The old in that way becomes a steppingstone to the new. This is a contribution which is made by Thomas Nelson and Sons in their Loose-Leaf method of publishing recent discoveries. Renewal pages for "Diagnostic Roentgenology", edited by Dr. Ross Golden, are so arranged that they may be substituted for, or added in the proper order to those which have previously appeared, and thereby preserve the continuity of the different chapters. With the 600 pages just issued, the second renewal service, the work on this subject has now become expanded into two volumes, and a binder for Volume II is included. In addition to the new material, there is a revised index, table of contents, and list of contributors.

The work has already earned its place in the field of medical literature, and now, in addition to the revision of the subjects already published, there are in this present series five new chapters by authors well known from their position in their special departments. These new chapters are on the following subjects: The Roentgen Diagnosis of Fractures and Dislocations, Roentgen Diagnosis in Infants and Children, Soft-Tissue Roentgenography, Laminagraphy, and Angiography. The revision of the chapter on Roentgen-Ray Diagnosis of Diseases of the Skull and Intracranial Contents comprises 230 pages with 336 illustrations, and there is an addendum to the chapter on Radiology of the Chest.

As in the first two of the series, the text is supplemented by many roentgenograms, excellently reproduced.

SEPTIC SPONDYLITIS. REPORT OF SEVEN CASES. Lars Holmberg. *Acta Chirurgica Scandinavica*, LXXXIV, 479, 1941.

A detailed review of seven cases of septic spondylitis furnishes an opportunity for a study of this subject. Five of the cases were caused by staphylococci, one by streptococci, and one perhaps by the influenza virus. Trauma was not considered of importance. In three cases there were double isolated lesions, two of them involving the laminae. Three patients were under twenty years of age and four were over. Six cases were acute with abscesses, and one was chronic without an abscess.

The roentgenogram is of assistance in the early diagnosis by showing the shadows of abscesses and oedema. Later in the disease, the roentgenographic appearance differs from that of the tuberculous spine. The writer suggests that the septic lesion usually starts in the "diaphyseal part". It usually has uneven edges with a regenerative reaction in the surrounding tissue.

The treatment consists of incision of abscesses and immobilization of the affected part. In every case healing occurred, but there was some stiffness of the back.—*Walter P. Blount, M.D., Milwaukee, Wisconsin.*

Über Calcaneusfrakturen (Fractures of the Calcaneum). Thore Olovson. *Acta Orthopaedica Scandinavica*, XI, 199, 1940.

A statistical review of 448 cases of fracture of the calcaneum from the files of the National Insurance Company of Stockholm, from 1924 to 1933, show that these fractures have been increasing in frequency in recent years. They represented 0.68 per cent. of the total fractures registered and 4.9 per cent. of all fractures of the bones of the foot. Forty and two-tenths per cent. were caused by falls from ladders; 23.5 per cent., by falls from scaffolds. The average height of the fall was three and four-tenths meters. In the falls from greater heights, both extremities were fractured, and the indemnity was larger. Additional fractures were found in 8.7 per cent. of the cases. Forty-three per cent. of the fractures were on the right and 55 per cent. were on the left.

Prior to 1929, the method of treatment was conservative without reposition of the fragments. After that year, active reduction according to the methods of Böhler and Westhues was used more. Some improvement in late end results was noted after the establishment of active treatment.—*Walter P. Blount, M.D., Milwaukee, Wisconsin.*

Contribution to the Knowledge of Congenital Dislocation of the Hip Joint. Late Results of Closed Reduction and Arthrographic Studies of Recent Cases. Erik Severin. *Acta Chirurgica Scandinavica*, LXXXIV, Supplementum 63, 1941.

In one of the most thorough, and certainly the most critical, end-result studies of congenital dislocation of the hip to be produced, Severin offers a detailed study of the results, which were primarily successful, in 330 patients with 454 treated hips from 1913 to 1932. Only four patients were lost. All of the hips were treated by the method of Dr. Haglund and under his direction. Reexamination (not questionnaire study) five to twenty-seven years after treatment showed the following roentgenographic-anatomical condition:

		Per Cent.
"I	Well developed hips roentgenologically	4.24
II	Moderate deformation of the femoral head, neck, or acetabulum, but a well built joint otherwise	7.14
III	Dysplasia, not subluxation	8.04
IV	Subluxation	43.75
V	The femoral head in a secondary acetabulum in the upper part of the original one	12.95
VI	Re-dislocation	16.96
Dead		5.58
Not re-examined		1.34"

All of the groups except the first showed deformity of the femoral head and neck. Early treatment gave the best results, and the writer agrees that treatment should be begun as early as possible.

Fifty-seven of the "health" hips in the 190 unilateral cases showed a definite dysplasia or subluxation.

Functional results were better than the roentgenographic-anatomical ones, but good function was frequently reported in the cases with poor anatomical results. It was noted that function in such cases deteriorated as did the anatomical appearance of the joint with the passage of time.

Arthrographic studies were made on normal and on abnormal hips in children. It

was found that when a fully dislocated hip was reduced after the age of one year, the limbus, immediately after reduction, did not embrace the femoral head to the normal extent, but gradually did so within the next few months, if the reduction was maintained. It was also discovered from arthrography that changes of the capital nucleus of the coxa plana type may be associated with deformity of the cartilaginous head, but may occur also with retention of the spherical shape of the head. Usually the shape and size of the femoral head became normal during the first year following reduction.

This monograph could certainly be read with profit by every orthopaedic surgeon who is called upon to give a prognosis in cases of congenital dislocation of the hip.—*Walter P. Blount, M.D., Milwaukee, Wisconsin.*

DIE FRONTALE WIRBELKÖRPERSPALTE (Frontal Fissure of the Vertebrae). Folke Knutsson. *Acta Radiologica*, XXI, 597, 1940.

In 1931 Loosen described a thirty-centimeter foetus, in which the vertebral bodies presented evidence of a frontal fissure. The present author has had occasion to observe three similar cases. In one case, death occurred from an oesophageal malformation. At autopsy, the appearance of the fissure was found to be due to the persistence of cartilage between an anterior bony nucleus and a posterior bony nucleus, which normally occurs in the body of the vertebra. In the other two cases, the fissure was found to involve not only the lumbar, but also the thoracic area of the spine. In these the fissure was found to have closed within two to four months, leaving a normal-appearing vertebral body.

In the opinion of the author, the frontal fissure is a normal stage in the bone development of the vertebral body. It is usually found within the first month of birth and normally disappears within two to three months. Of course, no treatment is indicated.—*Henry Milch, M.D., New York, N. Y.*

SOME CASES OF SOLDIER'S FRACTURE. Jens Munck Nordentoft. *Acta Radiologica*, XXI, 615, 1940.

"Soldier's fracture" has appeared in the literature under the designations of insufficiency fracture, osteopathia itineraria, stress injuries, and work periostitis. Typically, the metatarsal bones are the site of the injury. But the tibia, the fibula, the pelvis, the femoral neck, and the lower end of the femur have been affected. These fractures occur as the result of mechanical strain, consequent upon continued, rhythmic, and unaccustomed work.

Therapeutically, these cases present no difficulty. The main problem arises in the differential diagnosis between them and the early stages of Ewing's sarcoma. Both conditions present roentgenographic evidences of "onion-peel" periosteal reaction, with thickening of the cortex. In doubtful cases, biopsy alone can establish the diagnosis. Four illustrative cases are presented.—*Henry Milch, M.D., New York, N. Y.*

ON BIPARTITE OS NAVICULARE PEDIS. Erik de Fine Licht. *Acta Radiologica*, XXII, 377, 1941.

Clinically, these cases present no characteristic features. Pain on walking or standing may be marked or very mild. There may be some restriction of motion and "examination oftenest shows an osseous prominence in the tarsal region, just in front of the medial malleolus".

"The roentgenographic picture, on the other hand, is very characteristic. In dorsoplantar projection one finds on one, or often on both sides, of the navicular, a wedge-shaped alteration of the bone, with the base of the wedge directed medially, the point laterally. Besides, one finds, lateral to the point of this wedge, a vague, indefinite shadow . . . [which] represents a small, dorsally situated part of the bone. In the side view this

shadow . . . is as a rule triangular, and may be more or less distinctly separate from the rest of the navicular."

The condition is probably congenital in origin. It may arise as the result of ossification of two separate nuclei, or as the result of the wandering of a secondary cuboid bone. The condition usually causes no symptoms in young individuals, but predisposes to the early development of arthrosis. The treatment must be orthopaedic and may justify surgical intervention.—*Henry Milch, M.D., New York, N. Y.*

ANEURYSM OF AN INTERCOSTAL ARTERY WITH SIMULTANEOUS, SACROMATOUS DESTRUCTION OF AN ADJACENT, DORSAL VERTEBRA. Nils P. G. Edling. *Acta Radiologica*, XXII, 411, 1941.

Apart from a purely theoretical speculation as to the etiology of the two conditions, the paper is interesting for the details of the case.

A year before admission to the hospital, the patient began to complain of digestive trouble, an abdominal pain under the right costal arch, radiating up the back and into the right shoulder. On admission, an area of dullness was detected below the right scapula, close to the spinal column.

The roentgenogram revealed "a round, dense area, the size of an infant's head with sharp, evenly-rounded outlines, within the lower portion of the right pulmonary field adjoining the heart shadow". It was situated close to the spinal column, from which it could not be projected. "The center of the dense area was on a level with the ninth dorsal vertebra, which showed signs of destruction."

Aspiration of the mass, after costal resection, revealed a few cubic centimeters of blood. No tumor mass could be palpated through the pleura.

At autopsy, the vertebra was found to be the site of an osteogenic sarcoma. The rounded mass seen on the roentgenogram was considered to be an aneurysm of an intercostal artery. The mass extended from the seventh to the tenth thoracic vertebrae, and was largely extrapleural, but the communication with the involved intercostal artery could not be demonstrated.

The condition must be differentiated from an encapsulated exudate, primary osteogenic sarcoma, mediastinal lipomata, fibromata, or neurinomata, and metatastic neoplasia.—*Henry Milch, M.D., New York, N. Y.*

FRACTURES OF THE SPINE AFTER METRAZOL CONVULSIVE THERAPY AND OTHER CONVULSIVE STATES. M. M. Pearson, and H. W. Ostrum. *The American Journal of Roentgenology and Radium Therapy*, XLIV, 726, 1940.

Thirty-two patients undergoing metrazol therapy were studied from the standpoint of damage to the vertebrae. Unlike the usual compression fracture which occurs in the lower thoracic or upper lumbar regions, the compression in these patients undergoing metrazol therapy was found to occur chiefly from the fourth to the seventh thoracic vertebrae. A mechanical cause of the compression fractures is favored by the authors. Of the thirty-two patients, fourteen (43.9 per cent.) showed multiple compression fractures. No correlation between their occurrence and the total number of convulsions, dosage, or age of the patient was found.

The authors make a plea for roentgenographic examination of the spine to be made more frequently after convulsions of any etiology.—*J. D. Blair, M.D., Iowa City, Iowa.*

INSUFFICIENCY FRACTURE OF THE TIBIA RESEMBLING OSTEOGENIC SARCOMA. George E. Pfahler. *The American Journal of Roentgenology and Radium Therapy*, XLV, 209, 1941.

The author first reviews the literature and known facts concerning this type of fracture. He describes it as an incomplete fracture of the cortex of the bone, resulting from

excessive strain and affecting just one side of the bone. In most cases the fracture line is not discernible in the roentgenogram until after a month or more. The first symptom is pain on exertion at the site of the lesion, often with early swelling due to oedema, and with a later swelling caused by callus formation. The process is similar to that seen in the so-called "march fracture" of the metatarsals.

Since the pain and swelling with new-bone formation are often seen without the fracture line being visible, a diagnosis of osteogenic sarcoma is a natural mistake, and one which the author emphasizes as being a tragic one. Cessation of activity and weight-bearing will result in complete cure.

A case report with roentgenograms is also given.—*J. D. Blair, M.D., Iowa City, Iowa.*

RIGENERAZIONE SEGMENTARIA OSSEA MEDIANTE INNESTI ETEROPLASTICI. RICERCHE SPERIMENTALI (Segmentary Regeneration of Bones by Means of Heteroplastic Grafts). Vincenzo Liberti. *Annali Italiani di Chirurgia*, XIX, 389, 1940.

Experiments in animals as well as experience in surgery in man have proved that bone grafts made of foreign material do not take as well or as fast as material from the same animal or individual. The author studied experimentally the question of whether heteroplastic material could be treated before grafting, so that it would take as well as an autoplastic graft. He resected from the peripheral third of the tibia of rabbits, of the same age and weight, a segment one centimeter long, and implanted in the defect a bone graft taken from the vertebrae of oxen. He used that type of bone because of its spongy structure. Four series of experiments were performed. In the first series, the grafts, after being sterilized by boiling and then drying in air, were immersed for twelve hours in normal saline solution; in the second series, in citrated rabbit's blood; in the third series, in a 2-per-cent. solution of cholesterol in oil; and in the fourth series, in equal parts of rabbit's blood and cholesterol solution. After transplantation of the grafts, the legs were splinted, roentgenograms were taken at regular intervals, and the experiments were finished after two months. The legs were then dissected and examined histologically. While the results in the first two series showed no, or almost no, signs of penetration of the grafts with callus, the third and fourth series showed successful grafting. There was solid union between the two ends of the tibia and the graft, and microscopically a definite reaction of the periosteum and infiltration of the medullary spaces of the transplant with bone tissue had taken place.

The author comes to the conclusion that it is well worth while to do heteroplastic instead of autoplastic grafting in bone surgery, provided the graft has been previously treated with cholesterol.—*Josef Wolf, M.D., Davenport, Iowa.*

PLASTICHE A DISTANZA CON LAMINE DI GOMMA IN LESIONI SPERIMENTALI DI FASCI NERVOSI (Bridge Plastic with Sheet Rubber in Experimental Lesions of Nerve Bundles). G. Giangrasso. *Annali Italiani di Chirurgia*, XIX, 561, 1940.

While in lesions of the peripheral nerves, suturing end to end is successful in as many as 80 per cent. of the cases, nerve repair, when part of the nerve is missing and has to be bridged, is still unsatisfactory. Since in war wounds this type of injury is quite frequent, new research on this subject is timely. Many methods have been devised to bridge the defect in peripheral nerves without much success. Materials which have been previously used to connect the two ends of the nerve are silk; catgut; autoplastic, homoplastic, and heteroplastic nerves; and tubes made of bone, glass, an alloy composed of magnesium and aluminum, hardened gelatin, hard rubber tubing, segments of veins and arteries, and the trachea of hens. The author assumes that some of the poor results, when tubes of inorganic material were inserted, are due to the fact that their walls are impermeable for the circulation of nutritional fluid coming from the lymph spaces of the neighboring tissue. Since rubber sheets have proved superior to other foreign material

in arthroplasty (See *The Journal of Bone and Joint Surgery*, XXIII, 206, 1941), the author used it experimentally in nerve lesions. Under local anaesthesia with a solution of 1-per-cent. procaine he dissected from the sciatic nerve of rabbits a piece two centimeters long. Paralysis of the leg, oedema, and trophic ulcers followed. He then implanted a rectangular piece of rubber sheet about four by one and one-half centimeters, and wrapped it around the two ends of the nerve as one rolls a cigarette, sealing it with collodion and stabilizing the "cigarette" by suturing the rubber tube with fine catgut or silk to the perineural tissue. For sheet rubber he used the same material as is in rubber gloves. It was sterilized by boiling in distilled water for thirty minutes, then preserved in a solution of 5-per-cent. phenol, and immediately before use again sterilized by boiling in distilled water for fifteen minutes. Biopsies were performed in the animals, operated upon in the described manner, between ten days and six months after the operation. After three weeks the defect between the two ends of the nerve was completely filled with nerve tissue, which at first showed a rather disordered texture, but later the nerve fibers grew in parallel bundles. In all cases the paralysis, oedema, and trophic ulcers disappeared, and there was complete restitution of function. The method was then used clinically in one patient with a defect of the radial nerve above the elbow joint, with perfect result.—*Josef Wolf, M.D., Davenport, Iowa.*

SULLE CONSEGUENZE DELL'AZIONE DEL FREDDO NELLE EPIFISI DI ANIMALI IN ACCRESCIMENTO (On the Action of Refrigeration upon the Epiphysis of Animals During Growth). G. B. Cengiarotti. *Annali Italiani di Chirurgia*, XIX, 607, 1940.

The pathological and anatomical appearance of an epiphysis damaged during growth by freezing resembles the picture of disturbed epiphyseal growth. However, the nature of the damage, whether caused directly by destruction of the cells or indirectly by impaired circulation, has not been studied before, and is now clarified by the author's experiments. He dissected the lower femoral epiphyses of young rabbits and sprayed them with ethyl chloride for three minutes, after which time the bone was as hard as stone, and of glassy appearance. He let the epiphysis thaw out and repeated the spraying eight to ten times, so that the total time of refrigeration was twenty-five to thirty minutes. Such a procedure proved more satisfactory than prolonged refrigeration for ten consecutive minutes, since the latter caused too much damage to the neighboring tissue and spoiled the experiment. While there were some zones of necrosis and ulceration in the soft tissues, they healed within a short time. The bone lesions were entirely different. During the first two months after the freezing, no change was observed; during the third month macroscopic, microscopic, and roentgenographic changes were visible. The joint cartilage showed cellular disorder,—zones of regular pattern were interspersed with nests of cells of different shapes, pycnotic nuclei, and vacuoles. Furthermore, fatty degeneration and fat embolism of the small blood vessels were evident, and, finally retarded growth, and deformity of the femur. It appears, therefore, that the damage caused by freezing of the growing epiphysis is due to impaired blood circulation.—*Josef Wolf, M.D., Davenport, Iowa.*

PLASTICHE PERITENDINEE SPERIMENTALI CON LAMINE DI GOMMA (Experimental Peritendon Plastic with Sheet Rubber). G. Giangrasso. *Annali Italiani di Chirurgia*, XIX, 766, 1940.

The author studied experimentally the fitness of sheet rubber for artificial tendon sheets. He injected into the Achilles tendon of rabbits a few drops of a culture of staphylococcus pyogenes aureus in broth. The following circumscript infection healed with a scar firmly connecting the tendon with the neighboring tissue. Six months after the first operation, he excised the scar and wrapped a piece of rubber sheet around the Achilles tendon. The technique was the same as that used for nerve plastic (See abstract, p. 222). Biopsies, performed between two weeks and six months after the second operation, showed that the rubber sheet blocked the growth of the peritendinous tissue

into the tendon, and the tendon had full play within the artificial sheet. The author assumes that this type of alloplastic is superior to any other hitherto employed, and recommends its use, since he feels it has successfully passed the experimental stage in surgery.—*Josef Wolf, M.D., Davenport, Iowa.*

NEUROLOGIC SYNDROMES ACCOMPANYING DEVELOPMENTAL ANOMALIES OF OCCIPITAL BONE, ATLAS AND AXIS. Carl E. List. *Archives of Neurology and Psychiatry*, XLV, 577, 1941.

The author discusses anomalies of the occipitocervical region of the spine and the neurological findings, and reports seven cases. Three mechanisms may be responsible for the neurological signs:

1. Bone deformity causing mechanical compression of the neuraxis.
2. An associated, though independent malformation of the nervous system, not a direct consequence of the bone lesion.
3. A combination of the two foregoing mechanisms.

The bone deformities present in the author's patients were:

1. Malformation of the occipital foramen; basilar impressions (platybasia).
2. Fusion of the atlas with the occiput; malformation of the atlas.
3. Fusion of other cervical vertebrae; malformation of these vertebrae.
4. Abnormal position of the axis in relation to the occiput and atlas.

The author discusses the neurological signs associated with basilar impressions, anterior dislocation of assimilated atlas on axis, and developmental anomalies of the nervous system.

The patient with a congenital deformity of the craniovertebral junction is usually an adolescent or young adult, who complains of suboccipital pains, stiff neck, unsteady gait and signs of progressive tetraparesis of many months' duration. Examination shows a stigmatized person, with an unusually short neck, which is held rigidly, in a rotated or hyperextended posture. Neurological findings consist of tetraparesis combined with cerebellar signs and nystagmus, and occasionally symptoms of increased intracranial pressure. Roentgenograms show bone deformity, especially in the lateral view.

Treatment consists in (1) the decompression of the medulla oblongata and cervical portion of the cord; and (2) immobilization of the head in relation to the neck.

The author operated on six patients; three died of respiratory failure, and three were markedly relieved.—*T. J. Greteman, M.D., Iowa City, Iowa.*

MALIGNANT TUMOURS OF TENDON SHEATHS. E. S. J. King. *The Australian and New Zealand Journal of Surgery*, X, 338, 1941.

Seven cases of synovial sarcomata are described in detail to emphasize the peculiarities of the malignant type of synovial tumor.

In general, the tumors are well delineated and are attached to a tendon sheath originally. After a latent phase, they suddenly increase in size and invade neighboring tissues, occasionally metastasizing to regional lymph nodes, liver, and lungs.

Microscopically, the tumors present a varied appearance, but there is an abundance of closely packed spheroidal or spindle cells with mucoid interstitial material and synovial spaces. These have a lining of connective tissue resembling normal synovial membrane. This lining membrane compares with that found in osteo-arthritic joints, and can be distinguished only by the presence of mitotic figures and by examination of the adjacent tissue.

Local excision of these tumors is unsuccessful, since in six of the seven cases there were recurrences or metastases. Radium implantation, together with wide excision of the tumor mass, has given the only satisfactory results.—*Daniel H. Levinthal, M.D., Chicago, Illinois.*

COMPOUND FRACTURE OF THE LEG. Fay Maclure. *The Australian and New Zealand Journal of Surgery*, X, 354, 1941.

This article, originally presented in October 1939, treats compound injuries from two standpoints,—first, that of generalized shock, and, second, that of the local injury. Shock is treated with transfusions. If primary amputation is necessary, the author prefers a below-the-knee stump of satisfactory length. In secondary amputation for sepsis he prefers a disarticulation through the knee joint, as this procedure requires the least trauma and provides a maximum of drainage. Antitetanus and anti-gas-gangrene sera should be given prophylactically and curatively as well, combined with sulfonamide drugs. Excision and débridement of a wound *en bloc* is the ideal, which cannot often be carried out; hence the author feels that open drainage is next of choice and advocates smearing vaselin or bipp onto the wound to keep it open. In using splints and traction devices, he cautions that the splint must be free-swinging, so that none of the patient's movements during ordinary bed rest will cause motion at the fracture site.—*Daniel H. Levinthal, M.D., Chicago, Illinois.*

A CONSIDERATION OF CERTAIN DIMENSIONAL FACTORS INVOLVED IN THE INTERNAL FIXATION OF THE FEMORAL NECK. D. J. Glissan. *The Australian and New Zealand Journal of Surgery*, X, 368, 1941.

From the premise that two ordinary rustless-steel nails will satisfactorily hold a fractured femoral neck, the author has developed a method for inserting the nails according to predetermined dimensional data. He measured thirty-seven specimen femora to determine the axial length of the neck, practical angle of the neck and shaft, and diameters of the head and neck; but, since these figures vary widely, he finds that they are of use only as minimal and maximal values. The author offers the inner angle of declination as an original contribution. This is the angle formed between the central cervical axis and the transverse axis of the pelvis. This angle is zero when the limb is fully medially rotated; hence the nail can be driven in parallel to the plane of the pelvis. Two nails of a resilient quality offer good fixation without causing as much damage to the bone as a flanged Smith-Petersen nail.—*Daniel H. Levinthal, M.D., Chicago, Illinois.*

COXA PLANA, WITH SPECIAL REFERENCE TO ITS PATHOLOGY AND KINSHIP. H. Jackson Burrows. *The British Journal of Surgery*, XXIX, 23, July 1941.

"1. Coxa plana proves histologically to be a condition of necrosis of bone followed by repair.
2. The necrosis differs from ordinary aseptic necrosis in showing lysis of trabeculae.
3. Infection cannot be excluded as a cause of the lysis, but is highly improbable.
4. The results of animal experiments suggest that the lysis is not due to arterial anaemia occurring in the special anatomical circumstances of the presence of bone in an envelope of cartilage.
5. A possible cause is some form of vascular disturbance other than arterial anaemia,—either venous obstruction or haematoma; the anatomical circumstances are such that either of these events might have profound results.
6. Recogniton of the special pathological changes assists the accurate definition of 'osteochondritis juvenilis' occurring at sites other than the hip and the rejection of alleged examples which lack the essential criteria which might properly justify an analogy with coxa plana.
7. Recognition of histological criteria suggests that the following are akin to coxa plana: osteochondritis of the tarsal scaphoid bone (Köhler's disease), of the metatarsal head (Freiberg's disease or Köhler's second disease), and of the semilunar bone (Kienböck's disease).
8. On grounds of critical radiology, without histological information, it is probable that osteochondritis of the vertebral body in infants (Calvé's disease) and osteochondritis juvenilis of the capitellum (Panner's disease) are further examples.

9. Other alleged examples of osteochondritis juvenilis, with one or two possible exceptions, probably belong to unallied conditions and are not analogous to coxa plana.
10. In assessing these conclusions, only the weight it deserves should be accorded to evidence based on identity of histological appearances or the results of animal experiments."—*Ernest M. Daland, M.D., Boston, Massachusetts.*

ISCHIOFEMORAL ARTHRODESIS. H. A. Brittain. *The British Journal of Surgery*, XXIX, 93, July 1941.

Ischiofemoral arthrodesis is suggested as an alternative method of extra-articular fusion. This procedure can be offered to anybody below sixty-five, provided the operation is to be done for tuberculosis and the disease does not involve the ischium.

It is claimed that a graft of this type gives better support than a graft from the ilium to the greater trochanter. The approach to the ischium is easy, but blind. This procedure is of great use in the patient with smouldering disease, where iliofemoral arthrodesis would stir up the disease.

In 80 per cent. of the thirty-five patients operated upon by this method, bony union took place after one operation. In three patients a second operation was needed. The disease involved the graft in two instances and the operation resulted in a failure.—*Ernest M. Daland, M.D., Boston, Massachusetts.*

INTRACAPSULAR FRACTURES OF THE NECK OF THE FEMUR. FINAL RESULTS OF 75 CONSECUTIVE CASES TREATED BY THE CLOSED METHOD OF PINNING. A. L. Eyre-Brooke and K. H. Pridie. *The British Journal of Surgery*, XXIX, 115, July 1941.

This is a study of seventy-five cases treated with the Smith-Petersen pin by the Hey Groves method. All cases were followed for at least twelve months.

In this series the mortality within three months was 5.3 per cent. Signs of necrosis of the head were seen as early as two months and as late as seven months; necrosis occurred in 14.7 per cent. In each of these cases there was a fracture-shaft angle of less than 37 degrees.

In nine cases the method resulted in failure: in six cases (8 per cent.) the pin did not immobilize the fragments; in three cases (4 per cent.) there was suppuration in the wound. Fibrous union occurred in ten cases (13.3 per cent.). The pin was found to have penetrated into the hip joint in four cases. Bony union was obtained in forty-four (58.7 per cent.) of the cases treated.—*Ernest M. Daland, M.D., Boston, Massachusetts.*

TRANSVERSE OSTEOTOMY IN UNUNITED FRACTURES OF THE FEMORAL NECK. S. A. Jahss and B. J. Mintz. *Bulletin of the Hospital for Joint Diseases*, II, 143, 1941.

Sixteen cases of transverse osteotomy for ununited fracture of the femoral neck were studied. The operation is indicated, whether the case is a recent one or not. It may be used even in cases where the head is non-viable. Through an anterolateral incision, the upper end of the femur is osteotomized at the level of the lowest projection of the capital fragment. The shaft is then transposed medially, so that its upper end lies beneath the fracture site, thus eliminating shearing stress.

In 33⅓ per cent., union occurred across the fracture line, even in cases of long standing. However, where healing of the fracture did not take place, the functional result was still satisfactory.

"The operation is instrumental in relieving pain, restoring stability and effecting recovery of joint motions. It is relatively non-shocking and is adaptable to all age groups with equal safety." Errors in the technique of performing the operation are discussed.—*Henry Milch, M.D., New York, N. Y.*

THE SURGICAL TREATMENT OF LEG LENGTH DISCREPANCIES. Paul H. Harmon and William M. Krigsten. *Illinois Medical Journal*, LXXIX, 300, 1941.

The authors discuss the indications, operative technique, and relative value of three methods used for treatment of leg-length discrepancies: (1) epiphyseal arrest; (2) leg shortening; and (3) leg lengthening. Over 120 patients at the University of Chicago Clinics have had operations for epiphyseal arrest, many having had more than one epiphysis closed. There were no postoperative infections or deaths. In two patients the short leg overgrew the sound leg, but in several, especially in girls, the operation was performed too late to be effective. The tendency has been to arrest growth at the knee in the femur only, but now the authors state they would also fuse the tibial and fibular epiphyses. Epiphyseal arrest should rarely be done after the age of eleven or twelve in girls, and thirteen to fifteen in boys, as very little or no growth can be expected in the long bones.

Thirty-five patients, with more than two inches of shortening, had operative shortening of the femur in the sound side. Except in one case in which infection was followed with loss of bone grafts and slight angulation, the results were excellent, with union in all cases. This method of leg-length equalization is mathematically accurate when properly done, and, although it carries greater operative risk than epiphyseal arrest, it has wide application.

In ten patients, eleven leg-lengthening operations were performed, four on the tibia and seven on the femur. One patient died from cellulitis and septicaemia. In two patients there was massive sequestration of the femoral diaphysis, and in one of these a stiff knee also resulted. Leg lengthening, the authors state, has limited application. They believe it is indicated in certain patients who are short of stature, but should be done only by a limited group of surgeons who have had experience with this method.—*M. S. Friedman, M.D., Iowa City, Iowa.*

CALCIUM DEPOSITS IN THE SHOULDER AND SUBACROMIAL BURSITIS. A SURVEY OF 12,122 SHOULDERS. Boardman Marsh Bosworth. *The Journal of the American Medical Association*, CXVI, 2477, 1941.

The author examined, clinically and by roentgenograms, the shoulders of 6,061 unselected persons, and found 165, or 2.7 per cent., of the group had calcium deposits about the shoulder. Of the total group, 5,061 were followed over a three-year period. During this time seventy patients had symptoms of pain in the shoulder. The cases appeared more frequently in males below the age of fifty, and especially in patients whose work required long periods of use of the arms in abduction. The author feels that there is a definite occupational factor in the formation of these deposits. A few deposits were found to occur in as short a time as two months, but it was felt that the majority developed slowly over a number of months.

In diagnosing these cases, the author advocates the use of a fluoroscopic and spot-film roentgenographic technique to prevent the overlooking of otherwise obscure calcium deposits.

In treating these cases, it must be remembered that some will heal spontaneously. Others may be improved or cured by such means as heat (infra-red diathermy) or irrigation methods. The author, however, prefers surgical excision of the deposit as being the surest means of complete relief. After such a procedure, the patient may expect to return to work, without symptoms, in about three weeks.—*Louis J. Levy, M.D., Dallas, Texas.*

THE USE OF SURFACE ANESTHESIA IN THE TREATMENT OF PAINFUL MOTION. Hans Kraus. *The Journal of the American Medical Association*, CXVI, 2582, 1941.

This paper describes a method of treatment for impaired function, when pain is the factor responsible for the loss of motion or power. The treatment is the application of a surface anaesthetic (ethyl-chloride spray) combined with active motion. It is effec-

tive in: (1) sprains of all joints; (2) acute muscle spasm due to lumbago, acute bursitis of the shoulder, pulled muscles, and so on; and (3) chronic muscle spasm due to "low back pain", sciatica, chronic osteo-arthritis, shoulder spasm, and the like, so long as fractures or a complete tearing of ligaments, muscles, or tendons of the affected region are absent.

The painful region must be determined through active motion, and ethyl chloride sprayed on this area of skin. The patient then starts careful active motion of the part involved in the direction in which the motion has been painful and limited. As the patient carefully increases the movement, new painful areas will develop which should be sprayed. These treatments last from ten to thirty minutes, and immediately following, camphor liniment should be applied to the skin to avoid frostbite. Immediate normal use of the affected part can be allowed in a majority of cases, but excessive strain should be prohibited. The active motion should be continued for approximately five minutes from twice a day to once every hour. One treatment will suffice in minor involvements while several may be necessary in more severe cases.

Immobilization after treatment is contrary to the basic principle, and is never used.

—*Brandon Carrell, M.D., Dallas, Texas.*

PRIMARY MALIGNANT TUMORS OF BONE. Henry W. Meyerding and Jorge E. Valls. *The Journal of the American Medical Association*, CXVII, 237, 1941.

This study of 424 primary malignant tumors of bone, encountered at The Mayo Clinic during the past twenty-five years ending with 1934, was made in an attempt to evaluate the end results of various types of treatment for these tumors.

The tumors were divided into the following groups: (1) osteogenic sarcoma, (2) fibrosarcoma, (3) Ewing's sarcoma, (4) multiple myeloma, (5) giant-cell sarcoma (malignant), and (6) malignant tumors of bone non-surgically diagnosed as sarcomata without specification of type.

In the treatment of osteogenic sarcoma, surgical operation is the method of choice, as this tumor is highly resistant to irradiation. Irradiation is used mainly to delay growth where amputation or excision is not feasible. The five-year survival rate of these patients who were treated surgically was 23.4 per cent. There were no five-year survivals among the patients treated non-surgically.

The fibrosarcomata constituted a relatively small percentage of the entire series. The authors believe that the fibrosarcomata which occur in bone are more amenable to surgery than are the osteogenic tumors, and the method of choice whenever possible should be biopsy under tourniquet control and immediate amputation. If this is not possible, then radical excision followed by irradiation should be carried out. They point out that a biopsy should be taken wherever possible, and this is particularly true in Ewing's sarcoma. Excision, together with irradiation, or use of Coley's toxins, or all combined, gave survival for five years of 16.7 per cent. of patients who received such treatment. Among the 114 patients treated and traced, 21.2 per cent. survived five years.

The treatment of multiple myeloma was rather discouraging, and treatment proved of little avail. More than 50 per cent. were recognized as multiple at the time of the original examination.

Malignant giant-cell sarcomata accounted for only 1.6 per cent. of the primary malignant growths of bone. At the end of a five-year interval, 83.3 per cent. of the patients had survived. The authors' general impressions are that the roentgenological treatment of tumors is not a cure, yet it has a definite place in the treatment of bone tumors. They are convinced that surgical operation offers the best method of treatment for the majority of primary malignant tumors of bone, and they urge surgeons, roentgenologists, and pathologists to cooperate, believing that only through their combined efforts will diagnosis, prognosis, and therapeutic measures be improved.—*H. H. Beckering, M.D., Dallas, Texas.*

THE USE OF SULFANILAMIDE AND SULFATHIAZOLE IN ORTHOPEDIC SURGERY. J. Albert Key. *The Journal of the American Medical Association*, CXVII, 409, 1941.

The author reports the use of sulfanilamide and sulfathiazole powders in wounds, either separately or together. He finds that when a mixture of these two drugs is placed into the wounds, the rapidly soluble sulfanilamide gives an initial high concentration of this drug, whereas the more slowly soluble sulfathiazole exerts a more prolonged effect. He has been using these drugs, not only in compound fractures following adequate débridement, but has also been placing them in supposedly clean surgical wounds before closure. The drugs, by their bacteriostatic action, help inhibit infection until the natural body defenses can become effective.

In infected open wounds, after adequate drainage has been established, sulfathiazole, or the sulfanilamide-sulfathiazole mixture is used locally, and supplemented by sulfathiazole orally.

The author feels that hematogenous pyogenic osteomyelitis should be treated with sulfathiazole orally, but that the local infection in the bone should be drained as soon as the general condition of the patient allows operation. He does not feel that sulfathiazole sterilizes the abscesses, and cites a case in which he saw the infection metastasize to other bones while the patient was under sulfathiazole therapy.

In chronic osteomyelitis, sulfathiazole by mouth, over a considerable period of time, may reduce the amount of drainage. Following the work of Dickson and Diveley, the author has introduced sulfathiazole powder in selected cases of chronic osteomyelitis after sequestrectomy and saucerization, with healing by primary intention in fourteen out of seventeen cases. Surgery in such cases is preceded and followed by oral sulfathiazole.—*Louis J. Levy, M.D., Dallas, Texas.*

THE SUPRASPINATUS SYNDROME. SYMPTOMATOLOGY, PATHOLOGY AND REPAIR. David M. Bosworth. *The Journal of the American Medical Association*, CXVII, 422, 1941.

This article is an analysis of fifty-three cases treated by the author with follow-up results for the group. He describes the various types of "internal derangements" of the shoulder which he encountered, and outlines his method of treatment in each case. He explores the shoulder through an inverted L-shaped incision, turning back the deltoid and getting a wide exposure.

The author advocates fusion of the shoulder joint in cases of complete avulsion of the short rotator cuff or in cases of massive fibrillation of the tendons. He reports thirty cases of repaired tears of the supraspinatus tendon. In the treatment of these, the extensiveness of the repair depends on the extensiveness of the lesion, as the end results of mild and radical transplantations were essentially the same.

Seven cases of obliterative subacromial bursitis were treated by surgical severance of the adhesions followed by an abduction spica for six weeks. Good results were obtained in this way in those cases followed.

The author points out that early osteochondritis of the humeral head may present a clinical picture similar to a laceration of the short rotator tendons.—*Louis J. Levy, M.D., Dallas, Texas.*

OCCULT FRACTURES. Roland Hammond and Denis S. O'Connor. *The Journal of the American Medical Association*, CXVII, 500, 1941.

The authors reemphasize the warning given in 1908 by Sir Robert Jones to the effect that clinicians must not depend solely upon roentgenograms for the diagnosis of fractures to the exclusion of clinical judgment.

In spite of the great improvement in roentgenographic technique and interpretation since that time, there yet remain cases in which a fracture cannot be demonstrated, although clinical evidence strongly suggests it and later roentgenographic evidence con-

firms it. Such fractures are defined by the authors as "occult fractures", and they present twelve cases.

The authors advocate continuation of the program of improved education of technicians and better training of practitioners in the interpretation of roentgenographic findings alone or in collaboration with the roentgenologist, but they point out that in case of doubt the clinical findings should always take precedence over negative or inconclusive roentgenographic findings.—*S. L. Stovall, M.D., Dallas, Texas.*

SHOULDER AND ELBOW LESIONS OF THE PROFESSIONAL BASEBALL PITCHER. George E. Bennett. *The Journal of the American Medical Association*, CXVII, 510, 1941.

In discussing the "sore arm" of the professional baseball pitcher, the author divides the lesions of the shoulder into an anterior and a posterior group. In the anterior group are included traumatic irritation, fraying of the supraspinatus and biceps tendons associated with constant rotation of the humerus, similar traumatic irritation of the subacromial and subdeltoid bursae, irritation of the coracoid bursa by the head of the humerus in the "follow-through", and inflammatory processes in the various bursae of this region. Conservative treatment is usually effective and includes rest and the local application of heat, combined with removal of focal infections and improvement of general health in inflammatory conditions.

The characteristic posterior lesion, which may seriously limit the career of the professional pitcher, is an exostosis which develops at the posterior-inferior border of the glenoid fossa, probably due to the repeated strong pull of the triceps and posterior capsule. This deposit produces an irritation of the capsule and its synovial lining, giving rise to local pain and tenderness, and irritates the circumflex nerve, producing referred pain in the deltoid region. Symptoms appear only under the terrific strain of "hard pitching". Rehabilitation of the shoulder so that it can withstand this strain cannot be assured at the present time.

Elbow lesions of the pitcher include the presence of loose bodies in the olecranon and coronoid fossae, and other osteochondritic changes. These may interfere with complete extension of the elbow, but they produce few other symptoms. Surgery is usually successful, and there is little interference with the pitcher's career.—*S. L. Stovall, M.D., Dallas, Texas.*

THE PLIGHT OF THE ARTHRITIC. Russell L. Cecil. *Journal of the Medical Association of Georgia*. p. 318, July 1941.

The author calls attention to the large number of people suffering from chronic rheumatic conditions. He also calls attention to the lack of hospitals or medical facilities available for the care of these patients. Much better care is provided for those suffering from tuberculosis or cancer.

Arthritis is divided into two large groups: (1) the rheumatoid or infectious type, and (2) the degenerative type. Too often the seriousness of Type 1 is overlooked or not sufficiently stressed by the doctor in the early stages of the disease. Much can be done at this stage to prevent the patient from becoming a bedridden or badly crippled invalid. The multiplicity of remedies suggested for treatment is an indication that no specific or eminently satisfactory form of treatment has yet been devised. The most fundamental principle in the care of these patients is rest with the release from ordinary cares and responsibilities of daily life. Sanitoria especially qualified to treat these conditions would be ideal, but unfortunately they do not exist in this country except for a few where patients of considerable means can afford to go. Treatment should continue for at least six months, but the great majority of patients can not afford this. Institutions especially equipped for the study and care of arthritics are needed, as this disease is a public health problem.

Three forms of treatment are in general use: (1) vaccine therapy, (2) vitamin-D

therapy, (3) gold therapy. Each of these is discussed. Gold is a dangerous form of treatment, and requires close observation and frequent examinations of the blood and urine. In spite of its dangers, its beneficial effects seem to justify its use in rheumatoid arthritis.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

EXTERNAL PIN FIXATION FOR FRACTURES OF THE MANDIBLE. Rainsford Mowlem, J. L. Dudley Buxton, Alexander B. MacGregor, and John N. Barron. *The Lancet*, II, 391, October 4, 1941.

The authors describe an apparatus to control fractures of the mandible occurring behind the tooth-bearing area. A pair of crossed Kirschner wires are inserted into each fragment. Methods of locking each pair of wires into a unit and then joining the units to maintain reduction are described. The advantages claimed are: absolute fixation by extra-oral means, oral cleanliness, function at the temporomandibular joint, and simplified feeding. The disadvantage is the occasional necessity of treating the small residual scars. The authors have used the method in nineteen cases. They feel that it is applicable only to chosen cases, and that it should not be used to replace the simpler and more standard methods for the great majority of mandibular fractures. Details of the extra-oral bar are well illustrated both by drawings and photographs.—*Lenox D. Baker, M.D., Durham, North Carolina.*

IRRIGATION OF WOUNDS WITH HOT SULFANILAMIDE SOLUTION. Fred R. Adams. *The Medical Press and Circular*, CCV, 318, 1941.

The author stresses the importance of thorough débridement in any potentially infected wound. Mechanical cleansing following débridement is equally as important. This may be done by soap and water or by irrigations with physiological saline or hypochlorite solution.

The author notes the definite value of powdered sulfanilamide in preventing infection in open wounds, but calls attention to the fact that only 0.8 per cent. of the drug is soluble in the serum of the wound, and the bacteriostatic action is due entirely to the dissolved part, and not to the powder or crystals remaining in the wound.

However, if sulfanilamide is dissolved in water at a temperature of 60 degrees centigrade, a 6-per-cent. solution will result. The author's *in vitro* experiments have demonstrated that this solution at 60 degrees centigrade will destroy organisms found in periapical lesions and in infected root canals in ten seconds contact. Heat increases the bactericidal effect of sulfanilamide, and makes possible a more concentrated solution of the drug. Since the surface tension of a heated solution is lowered, it is possible for the solution to penetrate farther into the involved tissue. It is thus possible to use a heated solution of sulfanilamide in wounds, and to get a greater bacteriostatic or bactericidal power than by using crystals alone. The wound should be irrigated only once with the solution.—*Herbert E. Hipps, M.D., Marlin, Texas.*

THE SEQUELAE TO NERVE INJURIES. Harry Platt. *The Medical Press and Circular*, CCV, 371, 1941.

The disabling aftereffects of a peripheral-nerve injury are dependent on the influence of a number of different factors. Impairment of function due to loss of nerve conduction (paralysis, anaesthesia, paraesthesia) varies considerably in economic significance with the nerve involved. Mechanical aftereffects—such as joint stiffness, flail joints, ulceration, and contractures—naturally also contribute to the sum total of residual disability.

There is a comparatively high percentage of functional recovery following suture of the radial nerve. However, if suture of this nerve fails to restore function, it is better to do the tendon transplantation described by Robert Jones than to re-open the arm and attempt secondary suture.

The median nerve seldom recovers satisfactorily when primarily sutured. Recovery following secondary suture is unknown. The Bunnell-Mayer operation is recommended to restore opposition.

Suture of the ulnar nerve results in very little more recovery than does that of the median nerve. Even though complete recovery does not occur, the lesion is not disabling to the hand for the coarser movements such as are used by laborers; however, in the case of the finer movements of the musician or artist the hand is seriously disabled.

Brachial-plexus injuries are always grave. Traction injuries in adults often leave a seriously crippled limb with very little expectation of recovery.

The sciatic nerve seldom recovers satisfactorily following suture, and in the majority of cases, after ulceration and sepsis, amputation is the only logical procedure.

Tenodesis to correct foot-drop resulting from failure of recovery of the external popliteal nerve is seldom of permanent value and is not nearly so efficacious as the wearing of a walking appliance.—*Herbert E. Hipps, M.D., Marlin, Texas.*

Fractures of the Lower End of the Radius and Ulna. Arthur G. Ord. *The Medical Press and Circular*, CCV, 496, 1941.

The usual types of fracture and the subsequent deformities are described, and the special complications that are liable to arise are discussed. Tenosynovitis of the tendons of the abductor pollicis, the extensor pollicis longus, and the extensor pollicis brevis is usually due to the excessive tightness of the plaster over the anatomical snuff-box. Persistent numbness of the dorsum of the thumb may result from a similar pressure. Gross persistent oedema of the dorsum of the hand after forty-eight hours is most likely due to "rucking" of the dorsal plaster slab, and, if not immediately corrected, intractable finger stiffness will develop. Delayed union or non-union of the ulnar styloid results in tenderness over this area and weakened grip. Median-nerve injury is rare.

The fracture is reduced by traction, followed by palmar flexion and ulnar deviation. Anterior and posterior plaster splints are then applied. On the fourth day new splints, holding the wrist in 5 to 10 degrees of dorsiflexion, are applied. In a fortnight the plaster is removed and an elastoplast bandage is wound comfortably tight around the wrist.—*Herbert E. Hipps, M.D., Marlin, Texas.*

Dupuytren's Contracture. Arthur Rocyn Jones. *The Medical Press and Circular*, CCVI, 14, 1941.

The author discusses the relative significance of trauma, infection, irritation, and other factors in the causation of this condition, and concludes that it is due to some inborn or acquired predisposition which is encouraged by injury.

The treatment always should begin with the detecting and treating of any constitutional disturbances. If this is done early enough, before much contraction has occurred, frequently stretching and active extension of the fingers will bring about correction of the condition.

More radical treatment necessitates either subcutaneous cutting of the fascial strip or its complete dissection and removal from the palm. Often, in very severe cases, subcutaneous cutting must be done first to get the fingers partially straightened; then later, when more thorough cleansing and preparation of the skin is possible, the open operation can be done.—*Herbert E. Hipps, M.D., Marlin, Texas.*

Fractures of the Patella. G. O. Tippett. *The Medical Press and Circular*, CCVI, 162, 1941.

The author discusses certain little-recognized points in the surgical anatomy of the patella. Among these, he points out that the patella is of little use to the human knee except for protection. The patella is a sesamoid bone in the tendon of the quadriceps,

and many of the fibers of the tendon do not attach to the patella. The patella is shaped to move vertically in the femoral groove. Any irregularity of the posterior patellar surface is, therefore, liable to cause a traumatic arthritis of the knee joint. In a transverse fracture of the patella, the upper fragment is tilted anteriorly at the lower end, due to the attachment of some of the fibers of the suprapatellar tendon to the anterior surface of the bone.

Chip or longitudinal fractures may be treated by extension immobilization with plaster for eight weeks. The patient is permitted to walk.

Transverse fractures always need surgical attention. The torn lateral expansions of the quadriceps tendon should be closed, and the patella pulled together with strong catgut threaded through holes in the fragments. The leg must be immobilized in extension with a plaster cast extending from hip to ankle. The patient may be permitted to walk in a few days.

Comminuted fractures should be operated upon, and all fragments should be removed. The whole patella may be removed if it is extensively comminuted. The fragments should be dissected out from under the tendon and should not be cut out haphazardly. The remaining tendon fragments are sutured together as well as possible, and fascial strips may be used to strengthen the area if necessary. A posterior splint is applied for seven days, and then active flexion and extension of the knee is encouraged.

Compound fractures should always be treated by excision of the fragments.—*Herbert E. Hipps, M.D., Marlin, Texas.*

THE LOCAL USE OF SULFATHIAZOLE IN THE TREATMENT OF STAPHYLOCOCCAL INFECTIONS. PRELIMINARY REPORT. W. W. Spink and J. R. Paine. *Minnesota Medicine*, XXIII, 615, 1940.

The authors observed that while blood cultures remained sterile in patients with staphylococcal septicaemia after sulfathiazole had been administered, the organisms could be consistently cultured from localized lesions. Sixteen patients with localized staphylococcal infections were treated by the application of sulfathiazole directly to the lesion every few days in addition to immobilization and elevation of the infected area where possible, surgical drainage and débridement of devitalized tissue, and frequent irrigation of the infected area with warm saline or Dakin's solution to remove necrotic material which has an inhibiting action on sulfathiazole. In patients acutely ill, sulfathiazole was given also by mouth. Sulfathiazole was planted directly in the infected part in crystalline form, or in a one-per-cent. aqueous solution in the form of irrigant or wet pack, or one-per-cent. sulfathiazole suspended in cod-liver oil, or in cod-liver-oil ointment with vaseline base. Very little of the sulfathiazole appeared absorbed from local areas, as analysis of the blood showed only traces of the drug.

Four cases of extensive carbuncles, three cases of infected operative wounds, one decubitus ulcer, one corneal ulcer, two cases of chronic osteomyelitis, one pyopneumothorax, and one extensive subcutaneous abscess were treated by this method with marked success. The successful clinical results obtained justify further investigation of this form of therapy.

The authors quote the results obtained by Jensen and his associates at Minneapolis General Hospital. Primary wound infection developed in no case of their thirty-nine compound fractures treated locally with sulfanilamide, but infections developed in 27 per cent. of their ninety-four cases treated without local sulfanilamide.—*Eugene H. Silverstone, M.D., Iowa City, Iowa.*

THE USE OF GOLD IN RHEUMATOID ARTHRITIS. E. R. Gardner. *Medical Record*, CLIII, 321, 1941.

This paper is a report of 250 cases of rheumatoid arthritis treated in the author's private practice with solganal-B oleosum, a suspension in oil of aurothioglucose, an or-

ganic-gold combination. A course of treatment was initiated with a dose of ten milligrams once weekly for four weeks. This was followed by twenty-five and fifty milligram doses given once weekly for four weeks, and 100 milligrams given once weekly for nine weeks. After an interval of from eight to twelve weeks, a similar course of injections was given. It was necessary to give at least two courses and preferably more to assure a permanent result.

In addition, a dietary regimen of ample vitamin content and caloric value, physical and mental rest, support of acutely inflamed joints, and physiotherapy (hydrotherapy and massage) after the inflammatory stage had subsided were given.

The first symptom to be definitely relieved is pain; then ability to effect joint motion, reduction of the swelling, and improvement of appetite.

Cure was considered to be a return to a condition as nearly normal as the extent of joint destruction would permit. Those patients who experienced relief from pain, but had less increase of mobility than would be expected under the existing degenerative changes, were considered to have reacted favorably, rather than to have been cured.

In this series of cases, 70 to 80 per cent. of the patients responded favorably to treatment, and in 50 per cent. of the recent cases and 30 per cent. of those of over two years' duration, the patients were cured.—*M. Rosenbusch, M.D., Iowa City, Iowa.*

TREATMENT OF CHRONIC ARTHRITIS WITH GOLD SODIUM THIOSULPHATE. John C. Thompson, and C. K. Elliott. *Nebraska State Medical Journal*, XXVI, 44, 1941.

The authors review the literature of gold therapy for chronic arthritis, and report the use of gold sodium thiosulfate in eighteen cases of chronic arthritis over a period of six months. Four patients were given 700 milligrams or more, five, from 250 to 500 milligrams, and the remaining nine, 145 milligrams or less during this interval. Forestier considers that a total of 1500 milligrams should be given in divided doses during one course of treatment, and states that results as a rule are not evident until approximately three months have elapsed and about one gram has been given. Since only four patients of this series had received a sufficient quantity of the drug, the authors draw no conclusions from them and only present the case histories. Three of these four patients had marked clinical improvement and the fourth, at first improved, then suffered a relapse, and later improved again. One patient included in the series had an aggravation of symptoms following each injection, but after the injections were stopped was much better than before they were begun. In two patients an erythematous skin rash with pruritus developed after a single injection. One patient had a marked effusion of the knee joint, which disappeared after twenty-five milligrams of gold had been given.

Various preparations of gold are described. In the author's group of cases gold sodium thiosulfate was used in gradually increasing doses at five-day intervals, starting with ten milligrams and increasing up to twenty-five milligrams.

The minimum amount of the drug which is capable of producing maximum results is slightly over 100 milligrams of gold sodium thiosulfate (the total amount of the drug to be administered in one course of treatment). This may be increased to 1500 or 2000 milligrams if improvement is evident, but developing slowly, and the patient shows no evidence of any serious toxic symptoms.

Based on the reports of others and on their own experience the authors reach the following conclusions:

1. Gold is a potentially dangerous drug, and should be used with knowledge of its toxic reactions.
2. No patient should receive gold who has evidence of any real kidney impairment.
3. Patients giving a history of allergy and hypersensitiveness should be treated cautiously to avoid reactions.
4. Initial doses of gold should be small and later treatment should be the minimum quantity capable of producing a favorable result.
5. Treatment should be controlled by constant and adequate laboratory examina-

tions including blood findings, sedimentation rate, and tests of urine and renal function.

6. The advent of bronchitis, skin eruption, etc. should be viewed with alarm and continued treatment should be given in such cases in very small doses or stopped entirely.—*J. Y. Sher, M.D., Iowa City, Iowa.*

A Statistical and Roentgen Analysis of Two Hundred Cases of Bone and Joint Tuberculosis. Louis Nathanson and William Cohen. *Radiology*, XXXVI, 550, 1941.

Two hundred cases of proved tuberculosis, selected at random, are reviewed. One-half, from one to sixteen years, were taken from the pediatric service, the rest were adults from sixteen to seventy years.

There were forty-five males to fifty-five females in the pediatric group; seventy-five males to twenty-five females among the adults.

There was no marked difference in incidence according to races.

In the pediatric group, 55 per cent. of the lesions involved the spine, 21 per cent., the hip; in adults, 52 per cent. involved the spine, 18 per cent., the hip. The great preponderance were in weight-bearing bones in both groups.

The pediatric group showed a much larger incidence in the small tubular bones of the hands and feet, while the adult group showed more sacro-iliac and knee-joint involvement.

Vertebral involvement was least in the extremities of the spine, and most frequent from the sixth dorsal to the fifth lumbar. Multiple involvement was a common finding, and occurred more frequently in the pediatric group than in the adult. Osseous and pulmonary tuberculosis frequently occurred together, 42 per cent. of the younger, and 55 per cent. of the adult group having coincidental pulmonary infiltrations.

The marginal type of involvement of the vertebral body was most frequent in the adults. The central type, in which the disc may show no involvement and the joint space no narrowing, occurred usually in the younger group.

Tuberculosis of the shaft of a long bone is infrequent, but did occur, usually in conjunction with involvement of a joint. It resembles non-specific osteomyelitis, and is often a productive lesion.

A paravertebral abscess was demonstrated in 49 per cent. of the cases of spinal involvement in the pediatric, and 71 per cent. in the adult group. Its extension may not follow gravitational lines. It may be the only roentgenographic evidence of underlying bone disease.

In the opinion of the authors the diagnosis of bone and joint tuberculosis from roentgenographic findings alone is not only difficult, but often inconclusive.—*Edward N. Reed, M.D., Santa Monica, California.*

Newer Drugs in Treatment of Arthritis. K. K. Sherwood. *Northwest Medicine*, XXXIX, 452, 1940.

The author states that there are 6,000 treatments for chronic arthritis. For a frankly suppurative joint, sulfanilamide and its derivatives are indicated. In an acute infection there is a marked increase in the need for vitamin C which should supplement sulfanilamide. When inflammation becomes chronic, it is of benefit to simulate an acute attack by producing fever and leukocytosis through typhoid injections. After the disease is arrested, removal of the focal infection will prevent recurrences.

Sulfanilamide is of little value in the proliferative type of arthritis; these patients frequently have an idiosyncrasy to it and occasionally develop marked leukopenia. Removal of foci is of importance in the general health of the patient, but has no specific effect upon the joint itself. Vitamin C is often extremely depleted. One hundred milligrams of ascorbic acid, three times daily, is indicated. It is a matter of weeks before the blood level becomes normal.

Gold is of especial value in the chronic symmetrical atrophic arthritis with normal

white blood count and rapid sedimentation. Ten milligrams of gold thiosulfate, once or twice a week, is very beneficial and relatively inexpensive. Routinely, a check should be made on hemoglobin, white blood count, and urine at least once a month. The author believes that vitamin C protects against gold intoxication, and gives it routinely. Gold administration should be continued until the patient is well, improvement ceases, or signs of intoxication occur. The author has had no fatalities. Liver and kidney disease are contra-indications to the use of gold.

The foremost serious complications are dermatitis, purpura, hematuria, and jaundice. Dermatitis is preceded by itching, and, if the drug is stopped at this stage, the dermatitis will be mild. Purpura is rare; the use of freshly dissolved drug at each administration lessens its possibility. The onset of purpura or bleeding gums is an absolute contra-indication to the further use of gold. In four cases with this complication seen by author, good response was obtained by intramuscular injections of liver and vitamin C. Hematuria was found to occur only in ankylosing spondylitis. The use of gold in the latter condition is rarely good, and hematuria so frequent, that urine analysis is indicated before each dose. One patient receiving a total of twenty milligrams of gold sodium thiosulfate required a transfusion. Jaundice and acute liver atrophy are rare, and probably occur only with large doses. Pain in involved joints after the first few injections is common, and is no contra-indication. Stomatitis may indicate intoxication, but is mild with small doses. Iritis also may occur. Joint oedema with obscure etiology frequently shows deficient vitamin C, and a chemical analysis of the blood should be made. Foci of infection, if evident, should be removed.

Gold, in the absence of rapid sedimentation, and sulfanilamide, and foci removal have not been of value in senile hips or Heberden's nodes. Vitamin B in large doses has been helpful occasionally. It is analgesic and mildly laxative.

Vitamin B is curative in alcoholic and deficiency neuritis. Most cases of neuralgia, however, are due to toxic or focal infectious factors, and satisfactory results with vitamin B are not persistent. Focal removal with or without vaccine therapy is indicated. The author prefers powdered yeast by mouth for the more indefinite neuralgias, and intravenous or intramuscular thiamine for true neuritis.

Structural disintegration of joints requires orthopaedic treatment.—*Eugene H. Silverstone, M.D., Iowa City, Iowa.*

PSEUDOFRACTURES IN DISEASES AFFECTING THE SKELETAL SYSTEM. John D. Camp and J. A. L. McCullough. *Radiology*, XXXVI, 651, 1941.

These pseudofractures are transverse zones of rarification from one millimeter to one centimeter in width affecting various parts of the skeleton and usually symmetrical in distribution. They have been described under various names, among them "pseudofractures", "spontaneous fractures", "march fractures", and "multiple spontaneous idiopathic symmetrical fractures".

They occur (1) in malacic diseases, appearing as a transverse band of decalcification; (2) unassociated with malacic diseases, as fissures through the cortex on one side; or (3) as fusiform callus formation and periosteal reaction only.

Some have considered this a distinct disease entity; the present authors do not.

This condition has been observed in connection with osteomalacia, rickets, celiac disease, sprue, osteogenesis imperfecta, fragilitas ossium, hyperparathyroidism, osteitis deformans, and various other conditions, which cause weakening of the bone framework. It occurs most often in the long bones, usually in connection with excessive strains. Losser believes that there is no gross fracture, but rather the summation of a series of small cracks, comparable to the infractions in a piece of malleable metal, caused by persistent bending back and forth.

There are no characteristic signs or symptoms of pseudofractures.

Treatment is to be directed at correction of any associated disease and protection against excessive strain.—*Edward N. Reed, M.D., Santa Monica, California.*

LATE RESULTS IN BENIGN GIANT-CELL TUMOR OF BONE OBTAINED BY RADIATION THERAPY. T. Leucutia, E. R. Witwer, and George Belanger. *Radiology*, XXXVII, 1, July, 1941.

For the past twenty years giant-cell tumors of bone have been classed as benign, and their treatment has become conservative. Surgical attack by curetting and the use of escharotics combined with irradiation has been the most widely used method, but present trends are toward the use of irradiation alone. This has proved sufficient in several series of cases. It avoids the dangers and other drawbacks of surgical intervention,—a major one of which is the possibility that surgery plus irradiation may occasionally constitute the combination of irritants which cause malignant transformation.

With growing experience the technique of irradiation has changed toward smaller dosage, continued over a longer period of time. Such decrease in dosage has tended to lessen the irradiation reaction of these highly radio-sensitive growths.—*Edward N. Reed, M.D., Santa Monica, California.*

A PROPOSITO DEL OSTEOMA-OSTEOIDE DE JAFFE (About the Osteoid-Osteoma of Jaffe). J. L. Bado e P. L. Ibarz. *Revista Brasileira de Orthopedia e Traumatologia*, II, 139, 1941.

The authors give a historical review of osteoid-osteoma and present two cases with a detailed pathological and roentgenographic study. The authors confirm the findings of Jaffe, recognize the affliction as a clinical entity, and describe four types in accordance with the roentgenographic and histological data: the discrete, circular, rarefied limited type; the circular sequestrum type; the hypercondensed type; and the exostotic type. The only treatment is surgical removal.—*Emanuel Kaplan, M.D., New York, N. Y.*

COSTELLAS CERVICAES (Cervical Ribs). Achilles de Araujo. *Revista Brasileira de Orthopedia e Traumatologia*, II, 186, 1941.

The author presents an extensive study of the problem. The embryology, anatomy, and pathology are treated in some detail, and the bibliography on the subject is varied and includes references in several languages. The author gives a description of a case history of a cervical rib, deriving from the seventh cervical vertebra, which caused a complex syndrome involving the brachial plexus and the cervical sympathetic trunk. The patient suffered attacks of changes of voice, which was probably due to indirect impairment of the recurrent nerve, by compression of the efferent inferior anastomotic branches to the inferior sympathetic cervical ganglion. The surgical removal of the rib is described. Following the removal, the patient made a complete recovery. Photographs, roentgenograms, and drawings add to the lucidity of the subject.—*Emanuel Kaplan, M.D., New York, N. Y.*

LUXACIÓN RECIDIVANTE DE HOMBRO: PUENTE OSTEOPLÁSTICO CÓRACOGLENOIDEO. OPERACIÓN DE RICARDO FINOCHIETTO (Recurrent Dislocation of the Shoulder: an Osteoplastic Bridge from the Coracoid to the Glenoid. Ricardo Finochietto's Operation). V. J. Bértola. *La Revista de Medicina y Ciencias Afines*, II, 545, 1940.

There are numerous operations for recurrent dislocations of the shoulder and the author mentions several of them. He believes that the best operation is the one which deepens the cavity of the glenoid by means of a bone graft. This operation was described by Ricardo Finochietto in *Semana Medica* in 1939. The present author describes the operation in great detail with many good sketches and drawings illustrating the technique and operative plan. A free bone graft, usually employing a rib, is placed in a notch in the end of the coracoid process, with the other end placed in a hollowed-out area in the scapula just below the glenoid. The technique of the operation offers some technical difficulties, but the author solves them by cutting the subscapularis, and by

employing a new incision which he believes greatly improves the exposure. He makes one other innovation in the operative procedure, and that is a thorough exploration of all the structures in the region of the joint and the correction of any variations from the normal, such as a loose capsule, a torn subscapularis tendon, or other abnormality. The operation is certainly an interesting one, and offers a good method for deepening the glenoid fossa of the shoulder. No statistics are included and no end results are given.—*Louis W. Breck, M.D., El Paso, Texas.*

TRATAMIENTO QUIRÚRGICO DE LA LUXACIÓN CONGÉNITA DE LA RÓTULA (Surgical Treatment of Congenital Dislocation of the Patella). Carlos Urrutia U. *Revista de Ortopedia y Traumatología*, IX, 203, 1940.

The surgical procedures used in the treatment of congenital dislocation of the patella can be grouped as follows: (1) skeletal operations, (2) capsular and ligamentous operations, (3) muscular procedures, and (4) mixed procedures.

The skeletal procedures may be summarized as follows:

1. Correction of the genu valgum, thereby modifying the direction of the pull of the quadriceps tendon.
2. Elevation of the external femoral condyle with a bone block, thereby preventing lateral dislocation of the patella.
3. Deepening of the trochlear canal of the femur.
4. Excision of the patella.

The author merely recounts briefly the techniques of the various procedures, and makes no statements as to the particular indications for each.

The capsular-ligamentous procedures should be done if there is a great laxity of these structures. The main procedure used is the transplantation of the patellar tendon and tibial tubercle medially. This is frequently combined with inclusion of the medial portion of the capsule of the knee. Free fascial grafts may be used to anchor the patella medially.

The muscular procedures consist in transplanting other muscles, such as the sartorius, vastus internus, semimembranosus, and the rectus femoris, into the medial side of the patella, so that the patella, on contraction of the quadriceps, will also be pulled towards the medial femoral condyle.

The mixed procedures are the most effective and complete. These usually consist in transplanting the tibial tubercle and patellar tendon medially on the tibia, combining this with a muscular or ligamentous procedure.

The author reports thirty cases which have been treated surgically, most of them by mixed procedures. No statistical analysis of the results is given, but they were generally very favorable.—*Don King, M.D., San Francisco, California.*

TUMORES ÓSEOS A CÉLULAS GIGANTES (Giant-Cell Tumors of Bone). Domingo T. Muscolo. *Revista de Ortopedia y Traumatología*, IX, 301, 1940.

Giant-cell tumor of bone is typically solitary, seen usually in the upper tibia or lower femur in adults between the ages of twenty and thirty-five. It is characteristically in the epiphysis, but may later invade the metaphysis. Trauma may initiate the formation of a giant-cell tumor, but its etiological importance is decreasing steadily as knowledge concerning these tumors grows. The pathogenesis of these tumors is disputed, the main theories including inflammatory, neoplastic, and endocrine origin. Experimentally, evidence points to a fairly strong endocrine rôle, for parathyroid injections in animals produce areas of giant cells in the bone.

Grossly, these tumors usually occupy the epiphysis of the long bones, grow, expand the cortex, and may extend into the metaphysis. The cavity in the bone is trabeculated. The framework of the tumor is soft and red or yellow, depending on its vascularity, and the center may be necrotic. Microscopically, the characteristic feature is the giant

cell which is of variable size and shape. The stroma is made of numerous capillaries, and round and fusiform cells. The xanthomatous tumors are less malignant than the highly vascular ones. Histological section is advised, for this only can determine whether the tumor is benign or malignant.

The first symptom is pain. Later, expansion of the bone and pathological fracture may occur. Roentgenographically, a solitary multilocular cavity is seen in the epiphysis with no new-bone formation, and with integrity of the periosteum and articular cartilage. The main conditions with which giant-cell tumor are confused are: (1) simple bone cyst, (2) localized osteitis fibrosa cystica, and (3) sarcoma.

Occasionally, a giant-cell tumor undergoes malignant change, but this is very rare. The prognosis is very good, and the recurrences are usually due to faulty surgery. The best treatment consists in careful curettage of the cavity, then packing with bone chips and grafts. Amputation need be done only if the tumor is malignant. Roentgenotherapy should be employed only for tumors inaccessible to surgery, such as those in the vertebrae and skull.—*Don King, M.D., San Francisco, California.*

NEURODOCITIS DEL NERVIO CUBITAL EN EL CODO (Ulnar Neuritis at the Elbow). Valentine C. Girardi. *Revista de Ortopedia y Traumatología*, X, 15, 1940.

The commonest cause of ulnar neuritis at the elbow is a posttraumatic cubitus valgus, usually subsequent to a fracture-dislocation of the external humeral condyle. Other less common causes are: (1) non-union of a fracture of the internal humeral condyle, (2) exostoses, (3) chondromatosis, (4) arthritis deformans, (5) periarthritis or ankylosis of the elbow, (6) comminuted fractures of the trochlea. One of the earliest symptoms of ulnar neuritis is weakness of the adductor of the thumb, but after a variable period of time, the full-blown picture of ulnar-nerve palsy ensues. The treatment is entirely surgical. The best procedure is the transplantation of the nerve above the medial epicondyle. This is combined with a supracondylar osteotomy, if cubitus valgus is marked. Various procedures for the anterior transplantation are described,—that is, the nerve may be allowed to lie free in the subcutaneous tissue (Roux), covered with antecubital fascia (Jauregui), or a fascia lata graft (Adson), or the nerve may be transplanted to lie over the anterior surface of the humerus below the common flexor aponeurosis of the internal epicondyle (Gutierrez).

It is to be emphasized that ulnar transplantation should be done early in the course of an ulnar neuritis if optimum recovery of function is anticipated.

The author reports nine cases of delayed ulnar neuritis, all of which were relieved by transplantation of the ulnar nerve.—*Don King, M.D., San Francisco, California.*

ESTUDIO EXPERIMENTAL DE LA LUXACIÓN ROTATORIA DEL ATLAS Y SU APLICACIÓN A LOS CONOCIMIENTOS ACTUALES (Experimental Study of Rotary Luxation of the Atlas). Enrique H. Lagomarsino y Héctor Dal Lago. *Revista de Ortopedia y Traumatología*, X, 121, 1940.

The possible movement in the atlanto-axial articulation is within the arc of 40 degrees, but in this movement, as seen from the side, two-thirds of the articular surfaces are not in contact. The lateral portion of the atlas which goes backward also descends, permitting the portion going forward to remain horizontal. The anatomical construction of the bones prevents locking of the articular surfaces. As long as the odontoid remains intact, the atlas can never be dislocated posteriorly. Based on these observations, the author states that in a rotary dislocation of the atlas the head must be turned at least 60 degrees, that the dislocation is maintained by muscular contraction rather than by bone locking, and that, because of the rotation of the head in a dislocation, a true frontal view of the axis cannot be obtained by transoral roentgenography.

In *unilateral rotary luxation* of the altanto-axial joint, the roentgenographic appearances are as follows:

The transoral projection will show articular compression of the side in which the wing of the atlas goes backward, a good lateral view (profile) of the side in which the atlas advances, and the axis in the center of the mouth, but rotated 60 degrees as shown by its transverse processes.

The lateral view of the axis will show, by rotation of the mandible, cephalic rotation; loss of contact of one articular surface of the atlas with one surface of the axis; the odontoid apparently dislocated posteriorly, because one wing of the atlas is advanced; and no rotation between the atlas and the occiput.

The lateral view of the atlas will show the axis rotated 60 degrees with respect to the atlas; the odontoid apparently in normal place; and no rotation of the atlas on the occiput.

In *isolated dislocation* of the atlas, a true frontal view of the axis can be obtained by transoral projection. The roentgenographic appearances are as follows:

Articular compression of the side of the atlas which goes backward; a good view of the side which advances; and slight displacement laterally of the odontoid toward the compressed side.

The lateral view shows rotation of the atlanto-axial surfaces; some occipito-atloid rotation; and apparent retrocession of the odontoid.

Unilateral non-rotary dislocation requires the rupture of the transverse ligaments for its production, and is not necessarily fatal, for the odontoid process may also be broken by the injury and will not be able to compress the spinal cord.—*Don King, M.D., San Francisco, California.*

CALCANIECTOMIA (DOS OBSERVACIONES). (Excision of the Os Calcis. Report of Two Cases). Sara Satanowsky. *Revista de Ortopedia y Traumatologia*, X, 443, 1941.

Excision of the os calcis is an operation which is rarely performed; its indications are tumor or tuberculosis or osteomyelitis of the bone. The tendo achillis is sutured to the plantar muscles and plantar fascia instead of being attached to the astragalus. Better function is obtained by this procedure, as the force of the muscles is transmitted to the forepart of the foot. After the operation the foot is immobilized in plantar flexion for a period of six to eight weeks.

The author presents two cases in which the os calcis was extirpated. One patient was a man, sixty-six years of age, who, following the operation, was able to walk a mile without discomfort. The other patient, a boy of twelve, walked with a slight limp, and there was marked weakness on plantar flexion of the operated foot. Weight-bearing in Case 1 was started at the end of a month; in Case 2 weight-bearing with a felt pad at the heel was permitted after three months.—*Leon Avila, Jr., M.D., San Salvador, El Salvador, Central America.*

MANIPULATION OF THE DORSAL VERTEBRAE. F. Guy Beauchamp. *Rheumatism*, II, 36, 1940.

Thoracic vertebrae are collectively movable to a lesser extent than the cervical and lumbar vertebrae, but do have greater rotary motion than the latter. In man the extensors of the spine are more powerful than the flexors. Inflammation of these extensor muscles produces weakness and stretching, with a consequent increase of the normal convexity in the thoracic area. As a result of this curve, the spinous processes of the seventh cervical and first thoracic vertebrae become unduly prominent. The head and neck appear to be set forward on the shoulders. In addition, when the condition becomes chronic, there is a marked limitation of motion present.

If the deformity is minimal, such patients may receive great benefit from manipulation. Described and illustrated are the following manipulations: springing up the thoracic vertebrae; freeing the scapula; forced extension of the thoracic vertebrae; and rotation of the thoracic vertebrae. All of them are effective in restoring motion upon carefully selected patients.—*Harold M. Childress, M.D., Charleston, South Carolina.*

TROCHANTERIC FRACTURES. Harry D. Morris. *Southern Medical Journal*, XXXIV, 571, 1941.

On the Tulane Service there were four times as many trochanteric fractures as there were intracapsular fractures of the hip. The mortality rate for trochanteric fractures varied from 24.3 to 39.3 per cent. in various clinics. The patients are usually older than those with true neck fractures. The average age of these patients was seventy-seven years. Under previous treatment with Russell traction or plaster casts, mortality was high (44 per cent.). Many decubitus ulcers occurred; nursing care was difficult and painful, and many stiff joints resulted. It was decided to try internal fixation of these fractures. All patients, without selection, are now operated upon as soon as possible after admission. In fourteen cases the Thornton plate and Smith-Petersen nail were used; two cases were treated by means of a long pin in the medullary cavity, and two by wires and screws. Local anaesthesia was used with all patients except the two with subtrochanteric fractures. Preoperative hypodermics of morphine and scopolamine were given. Roentgenograms of the normal hip, with a marker strapped on, were made to determine the length of the nail to be used. The Smith-Petersen nail was introduced, and its position checked by roentgenograms. Then a Thornton plate was added, on which three Sherman screws were used. Sulfanilamide crystals were used in the wounds in some cases, and the wounds were closed. The advantages of this method are freedom from pain after fixation, and no stiffness in the joints. Nursing care is greatly facilitated; the patient can be up in a rolling chair in a few days; stronger patients can use crutches in three or four weeks. In no patient did a pressure sore develop. The average hospital stay was reduced to twenty-nine and one-half days.

Two failures were due to errors in technique. The mortality was 33⅓ per cent.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

FRACTURES OF THE HUMERUS TREATED BY THE HANGING CAST. R. Arnold Griswold, D. C. Hutcherson, and E. C. Strode. *Southern Medical Journal*, XXXIV, 777, July 1941.

Over 300 cases have been treated by a hanging cast with satisfaction. All ambulatory patients are treated by this method except (1) children with extension supracondylar fractures, and (2) patients with extensive compound fractures which were treated first by skeletal traction, and later by the hanging cast after the danger of severe infection was passed. The method was adapted from that used in Caldwell's clinic in Cincinnati. After reduction of the fracture if necessary, a cast is applied from the knuckles to the axillary fold, with the elbow at right angles. A loop of wire or plaster, to which a sling is attached, is fixed to the cast at the wrist. The cast is allowed to swing free from this sling. The arm is not bandaged to the side, and the patient is instructed to be up and about, not to support the elbow, and to sleep in the Fowler position. Circumduction exercises of the shoulder are encouraged from the start. Fractures in the lower third are put up with the forearm in pronation. The position is checked by roentgenograms after one week. The cast is not advised for fractures of the surgical neck. Results have been more satisfactory by this method than by any other.

Primary open reduction, skeletal fixation, recumbent traction, or abduction methods are rarely necessary.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

TROCHANTERIC OSTEOTOMY FOR UNUNITED FRACTURES OF THE NECK OF THE FEMUR. J. S. Speed and Hugh Smith. *Southern Medical Journal*, XXXIV, 798, August 1941.

For non-union of the neck of the femur three methods of treatment are discussed:

1. Osteosynthesis (bone graft) is suitable for a limited number of cases in which the non-union of the fracture is of not more than two months' duration. The head must be viable, with not too much displacement or absorption of the neck, and the patient must be in good physical condition. The results are very satisfactory when union occurs, as

it does in about 60 to 70 per cent. of the cases. In about 25 per cent. of these patients subsequent osteo-arthritis develops.

2. The reconstruction operations are indicated in the presence of a non-viable head, advanced absorption of the neck, or excessive upward displacement of the trochanter. Approximately 60 per cent. have good or fair results. Dislocation of the neck or trochanter from the acetabulum may occur, and arthritic changes may result in a painful hip or knee joint.

3. Trochanteric osteotomies of either the high intertrochanteric, or the low or Schanz type have the mechanical advantages of:

a. The weight-bearing pedestal is shifted inward.
b. The shearing force of the fracture site is reduced, and the fracture line is more horizontal.
c. Following osteotomy the normal action of the glutei is preserved. In general the osteotomy is preferred to the reconstruction operation because:
(1) The operation is simpler and safer for elderly and debilitated patients.
(2) The mechanics of osteotomy give better weight-bearing.
(3) Subsequent displacement and loss of support are less likely.

4. Functional results are better than from reconstruction operations and approximate osteosynthesis.

5. The number of good and fair results is about 80 per cent.

In the majority of cases high osteotomy is better than low. The technique of the operation is described. There was no mortality in a series of thirty cases. The article is well illustrated.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

CONGENITAL PSEUDARTHROSIS OF TIBIA AND FIBULA. REPORT OF FIFTEEN CASES. J. Hiram Kite. *Southern Medical Journal*, XXXIV, 1021, October 1941.

The etiology, pathology, and general aspects of the subject are discussed. Then follows a review of fifteen cases seen at the Scottish Rite Hospital. In 8,000 patients under fourteen years of age, the incidence was 0.2 per cent. The bowing of the tibia was usually noticed at birth. In only one case was a fracture present at birth. In more than half of the patients the fracture occurred in the first year of life. One did not occur until the patient was nine years old. Four patients were seen and examined by roentgenograms before the fracture. The condition of the bones is described and illustrated. Four patients had had eleven operations before admission, one of whom had had six operations. Thirteen of the fifteen patients reported were operated upon at the Scottish Rite Hospital. Thirteen of a total of twenty-eight operations resulted in non-union, fourteen in bony union, and one was too recent to report. Three patients had refractures after bony union, but obtained firm union after a second bone graft.

Some authors believe that operation should not be attempted until after puberty, but this author believes the operation should be done in early life, because the leg develops better with use. The successful grafts were in patients from four to fourteen years of age. Various types of bone grafts were used, and the details of the operation are described. External fixation after operation is the most important. The average time the patient was in a plaster cast was nine and seven-tenths months, after which a brace was worn. The brace, which is described, was not removed until the roentgenograms showed good solid bone strong enough to bear the weight of the child. Some patients are still wearing braces. There was usually considerable shortening of the leg, requiring a cork sole two or three inches thick.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

BACK DISABILITIES DUE TO STRAIN OF THE MULTIFIDUS MUSCLE. CASES TREATED BY NOVOCAIN INJECTION. W. K. Livingston. *Western Journal of Surgery, Obstetrics and Gynecology*, XLIX, 259, 1941.

In a series of seventeen cases reported by the author, a definite localization of the "trigger-point" producing back pain was found to be in a small area on each side of the

mid-line of the lower part of the sacrum, in what the author calls the "multifidus triangle". In this area is found the lowermost origin of the multifidus and branches from the first three sacral nerves which supply the muscle in this region. In some cases of low-back disability the essential lesion may be small and local, while the syndrome of widespread muscle spasm, neuritis, and the pain phenomena may be due to secondary reflex disturbances. By accurate localization of the "trigger-point", and by the injection of this area with five to ten cubic centimeters of 2-per-cent. novocain deep into the multifidus, immediate relief of the local and reflex pain is produced. This is partly due to the anaesthetic effect of the novocain solution, and partly to the expanding force of the injection, both of which break down the vicious circle of reflexes. The relief is usually temporary and may be followed in a few days by an increase in symptoms with gradual improvement following. The injections are repeated at varying intervals. The results in five of the patients were classified as failures, four as improved, and eight as cured.

This method is not claimed to be a "cure all", but there is little doubt that the "multifidus triangle" plays an important part in back pain, and that the author has definitely contributed to our knowledge and treatment of back disabilities.—*F. Harold Downing, M.D., Fresno, California.*

THE CLINICAL SIGNIFICANCE OF ACCESSORY BONES OF THE FOOT. A. Gottlieb. M.D. *Western Journal of Surgery, Obstetrics and Gynecology*, XLIX, 452, 1941.

The author believes it is fallacious to regard supernumerary bones in the foot as of mere academic significance, and believes that they are potential sources of pathological manifestations. They may remain dormant and symptomless, but seemingly moderate injury or repeated microtrauma may effect a tear of the fibrous tissue in which each bone piece is invested, or it may induce its separation from the parent bone with which it forms a cartilaginous and capsular union. Four cases are reported:

Case 1. Bifurcated sesamoid became painful after trauma, and was cured by surgical excision.

Case 2. Os trigonum, or separated posterior tubercle of the astragalus, became painful following trauma, and was cured by surgical excision.

Case 3. Os tibiale externum, or accessory scaphoid, with persistent pain following trauma was only partially cured by conservative therapy.

Case 4. Os peroneum, or accessory bone, lateral to the cuboid, became painful after trauma, and was cured by conservative therapy.

These cases demonstrate that these bones are potential sites of traumatic inflammation and functional disturbance, and are subject to surgical correction.—*F. Harold Downing, M.D., Fresno, California.*

ÜBER DIE INJEKTIONSBEHANDLUNG BEI ISCHIAS (The Injection Treatment for Sciatica). Ernst Vaubel. *Zeitschrift für Rheumaforschung*, IV, 34, 1941.

Many forms of treatment have been used for sciatica or lumbago. While physical measures and baths have frequently given relief, certain cases have required modifications of such treatment. One of the most useful measures in the treatment of severe forms of sciatica has been the injection of local anaesthesia about the lumbar plexus or the sciatic nerve. The way in which the lesion is relieved is not entirely clear nor is the site of injection always the same. As the injecting solution the author uses 0.5 or 0.25 per cent. novocain in hypotonic (0.2 per cent.) sodium chloride. Schleich found that hypotonic sodium-chloride solution had an analgesic action. The combination of hypotonic saline with a weak solution of novocain has been found most effective. Seven cases are reported, most of the patients requiring several injections before they were completely relieved. One received fifteen plexus injections and ten peripheral ones. Physical and medical measures are also used. A review of the literature is given.—*John G. Kuhns, M.D., Boston, Massachusetts.*

DIE BEDEUTUNG DES RHEUMATISMUS NODOSUS INNERHALB DES RHEUMAPROBLEMS (The Significance of Nodules in Relation to the Study of Rheumatic Disease). A. Welz. *Zeitschrift für Rheumaforschung*, III, 510, 1940.

While nodules are not shown by the greater number of patients suffering from rheumatic diseases, they are helpful diagnostic signs. The author was able to study the nodules in patients during life and after autopsy. He found that the structure of the rheumatic nodules was not dependent upon the area in which they arose. There was a close relationship between the tissues of the joint capsule, fascia, tendons, and muscular connective tissue whether in the heart or in the voluntary muscles. These nodules are rarely found in the absence of rheumatic disease. The histological picture and the course suggest a specific excitant. The reaction may be an antigen-antibody reaction. A virus could also be the cause. Perhaps we are in a similar stage in rheumatic diseases to that of tuberculosis before the tubercle bacillus was discovered.—*John G. Kuhns, M.D., Boston, Massachusetts.*

RÖNTGENBEHANDLUNG DER RHEUMATISCHEN KRANKHEITEN (Roentgenotherapy in Rheumatic Diseases). Gunnar Kahlmeter. *Zeitschrift für Rheumaforschung*, IV, 57, 1941.

Kahlmeter reviews his experience with roentgenotherapy in rheumatic diseases. He feels that the therapy rests on a scientific basis since the observations and animal experiments of Pannevitz in 1933. How roentgenotherapy works is not entirely clear. The results have been found best in early acute cases, acute bursitis, and tendinitis. It has also been found useful in chronic arthritis and in neuralgia. Usually about 200 roentgen units are given once a week for six treatments. In gonorrhoeal arthritis over 90 per cent. were entirely relieved. Since the advent of sulfanilamide, however, roentgenotherapy is no longer used. In degenerative arthritis of the hip 50 per cent. remained unchanged. (Percentages in other forms of arthritis are not given.) After long experience the author feels that this is a most useful therapy with other procedures in the treatment of arthritis.—*John G. Kuhns, M.D., Boston, Massachusetts.*

DER TUBERKULÖSE RHEUMATISMUS. C. Frugoni. *Zeitschrift für Rheumaforschung*, IV, 203, 1941.

Frugoni, of the Medical Department of Rome University, believes that tuberculous rheumatism is a clinical reality, and that its diagnosis can be made definitely. Poncet differentiated four forms of this malady: arthralgia, and acute, subacute, and chronic arthritis. The subacute and chronic forms are most commonly encountered. In the differential diagnosis only gout and rheumatoid arthritis can be readily excluded. Involvement of bursae and tendon sheaths is of most importance for the diagnosis, as pleural effusion is for the lungs. The lymph nodes are not generally involved. There is no characteristic pathological picture. The disease is less a bacterial localization, than it is the reaction of the articular and periarticular tissue, in the nature of an allergy, to impregnation of the tissues with tubercle bacilli. In the clinical picture, the chief findings are articular changes, pain, and fever. Usually tuberculous infection is demonstrable in the body, and there is daily a slight fever. There is constant dull pain with exacerbations and in the joints inconstant effusion with tenderness and pain on motion. Injection of the articular effusion into guinea pigs at times shows tuberculous infection. Occasionally rice-like bodies can be felt in the joint. The disease is usually refractory to salicylates, and there is poor tolerance for heat. The tuberculin reaction is positive. The disease picture eventually becomes an outspoken tuberculous arthritis.—*John G. Kuhns, M.D., Boston, Massachusetts.*